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### CONTENTS

2 MAY 1989

#### Acoustics

- Stability of Plane Nonlinear Waves in Smoothly Inhomogeneous Random Media  
[Ye. S. Benilov; *ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI*, Vol 94 No 11, Nov 88] ..... 1
- Description of Elastic-Plastic Characteristics of Materials Loaded by Shock Waves from Kinetic Standpoint  
[A. I. Vorobyev, A. A. Gornovoy, et al.; *FIZIKA GORENIYA I VZRYVA*, Vol 24 No 4, Jul-Aug 88] ..... 1
- Shock Method of Synthesizing Cubic ZrO<sub>2</sub> Modification  
[S. S. Batsanov, D. L. Guryev, et al.; *FIZIKA GORENIYA I VZRYVA*, Vol 24 No 4, Jul-Aug 88] ..... 1
- Modeling Interaction of Shock Waves and Gas Inhomogeneities  
[P. A. Voynovich, A. I. Zhmakin, et al.; *ZHURNAL TEKHNIЧЕСКОY FIZIKI*, Vol 58 No 7, Jul 88] .... 1

#### Crystals, Laser Glasses, Semiconductors

- New Mechanism of Current Instability in Narrow-Band Semiconductors  
[A. A. Akopyan, S. S. Bolgov, et al.; *PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI*, 25 Oct 88] ..... 2
- Two-Stage Photogeneration of Charge Carriers in Exciplexes  
[N. G. Kuvshinskiy, V. M. Komko, et al.; *DOKLADY AKADEMII NAUK SSSR*, Vol 302 No 4, Oct 88] .... 2
- Research on Structure and Microhardness of Polycrystals of Cubic Boron Nitride  
[A. M. Mazurenko, A. A. Leusenko, et al.; *VESTSI AKADEMII NAVUK BSSR: SERYYA FIZIKA-MATEMATYCHNYKH NAVUK*, No 5, Sep-Oct 88] ..... 2
- Characteristics of Laser Action in Intrinsic Semiconductors During Electron-Beam Pumping  
[I. V. Kryukova, Ye. V. Matveyenko, et al.; *IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY*, Vol 24 No 8, Aug 88] ..... 2
- Radiation Emission by 4.4 GeV Electrons in Diamond, Silicon, and Germanium Single Crystals  
[A. O. Aganyants, Yu. A. Vartanov, et al.; *ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI*, Vol 94 No 8, Aug 88] ..... 3
- Temperature Dependence of <sup>4</sup>A<sub>2</sub>T<sub>2</sub> Transition Probability for Cr<sup>3+</sup>-ions in Y-Sc-Ga Garnet Crystal  
[M. A. Noginov, Yu. S. Privis, et al.; *ZHURNAL PRIKLADNOY SPEKTROSKOPII*, Vol 49 No 2, Aug 88] ..... 3

#### Gas Dynamics

- New Class of Multidimensional Flow Patterns in Compressible Media Admitting Exact Linearization of Navier-Stokes Equations  
[M. A. Demidov, A. P. Mikhaylov; *ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNIЧЕСКОY FIZIKI*, No 3 (169), May-Jun 88] ..... 4

#### Lasers

- Features of Formation of Radiation of Nitrogen UV Laser Excited by Creeping Discharge  
[P. P. Brnzalov, B. O. Zikrin, et al.; *PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI*, 26 Oct 88] ..... 5
- Effect of Powerful Ultrashort Light Pulses on Matter  
[Ye. G. Gamaliy, V. T. Tikhonchuk; *PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI*, 25 Oct 88] ..... 5
- Possibility of Laser Sounding of Shock-Compressed Plasma (SCP)  
[M. A. Sultanov; *ZHURNAL PRIKLADNOY SPEKTROSKOPII*, Vol 49 No 4, Oct 88] ..... 5
- Optoacoustic Absorption Spectra of Ethanol, Acetone and Benzene  
[L. S. Vasilenko, N. M. Dyuba, et al.; *ZHURNAL PRIKLADNOY SPEKTROSKOPII*, Vol 49 No 4, Oct 88] ..... 5
- Analogue of Ultrashort-Pulse Laser in Radio Frequency Range  
[M. N. Nersisyan, P. S. Pogosyan; *PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI*, 12 Oct 88] ..... 6

|  |   |
|--|---|
| Spectral Characteristics of Radiation of Flash-Lamp Dye Lasers With Selection of Generation Wavelengths by Phase Polarization Method<br>[A. P. Voytovich, L. P. Runets, et al.; ZHURNAL PRIKLADNOY SPEKTROSKOPII, Vol 49 No 3, Sep 88]   | 6 |
| Anomalies in Reflection of Surface Electric Waves by Metal Surfaces With Periodic Profile Upon Resonant Excitation of Such Waves on Such Surfaces by Laser Beams in Pulses of Finite Duration<br>[A. N. Dolgina, A. A. Kovalev, et al.; PISMA V ZHURNAL TEKHNICHESKOY FIZIKI, 12 Aug 88] | 6 |
| Diagnostic Laser Apparatus for Geophysical Experiments<br>[I. V. Moskalenko, L. Kh. Palmiste, et al.; PISMA V ZHURNAL TEKHNICHESKOY FIZIKI, 12 Aug 88]   | 6 |
| Relativistic Cherenkov Generator of Millimetric-Wave Radiation With ROD Resonator<br>[N. I. Gunina, S. D. Korovich, et al.; PISMA V ZHURNAL TEKHNICHESKOY FIZIKI, 12 Aug 88]   | 7 |
| Transverse Channelling and Free-Electron Laser on Strong Standing<br>[K. B. Oganessian, A. M. Prokhorov, et al.; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 94 No 7, Jul 88]  | 7 |
| Influence Of Collective Effects on Amplification in Locked Free-Electron Lasers<br>[V. A. Bazylev, A. V. Tulupov; FIZIKA PLAZMY, Vol 14 No 7, Jul 88]  | 7 |
| Ruby Laser With Feedback Through Phase Conjugation by Stimulated Brillouin Scattering<br>[A. A. Kovalev, L. V. Levashkevich, et al.; PISMA V ZHURNAL TEKHNICHESKOY FIZIKI, 12 Jul 88]  | 8 |
| Selective Laser-Type Ion Source<br>[G. D. Alkhazov, E. Ye. Berlovich, et al.; PISMA V ZHURNAL TEKHNICHESKOY FIZIKI, 26 Jun 88]   | 8 |
| Hot-Hole Semiconductor Masers and Lasers<br>[A. A. Andronov; VESTNIK AKADEMII NAUK SSR, No 6, Jun 88]  | 8 |

## Magnetohydrodynamics

|  |    |
|--|----|
| Temperature Regime of Heated Supercritical Pressure Channels Under Nonstationary Conditions<br>[I. I. Shmal, K. I. Soplenkov, et al.; TEPILOFIZIKA VYSOKIKH TEMPERATUR, Vol 26 No 5, Sep-Oct 88] | 10 |
|--|----|

## Nuclear Physics

|  |    |
|--|----|
| Theory of Interaction of Solitons of Q-Ball Type<br>[T. I. Belova, A. Ye. Kudryavtsev; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 95 No 1, Jan 89]  | 11 |
| Multipole Electromagnetic Moments of Neutrinos in Dispersive Medium<br>[V. B. Semikoz, Ya. A. Smorodinskiy; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 95 No 1, Jan 89]   | 11 |
| Spin and Statistics of Solitons in Film of Superflowing <sup>3</sup> He-A<br>[G. Ye. Volovik, A. Solov'yev, et al.; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, 10 Jan 89]   | 11 |
| Sound Amplification by Optical Radiation in Light-Absorbing Medium<br>[Al. A. Kolomenskiy; AKUSTICHESKIY ZHURNAL, Vol 35 No 1, Jan-Feb 89]   | 11 |
| Can Particles With Energies Greater Than $4 \times 10^{17}$ eV Be Neutrals?<br>[A. V. Glushkov; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, 25 Nov 88]   | 12 |
| Toroidal Excitons in Crystals<br>[Yu. V. Kopayev, N. V. Korniyakov; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, 25 Nov 88]   | 12 |
| Expanded Translational Symmetry in Theory of Multisublattice Magnetism, Spin Waves, Phase Transitions, Domain Walls and Antiferromagnetism of UX <sub>n</sub> Type<br>[A. L. Alistratov, D. A. Yablonskiy; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 94 No 11, Nov 88] | 12 |
| Analysis of Data on High-Energy Muons in Extensive Atmospheric Showers<br>[V. V. Vashkevich, P. F. Yermolov, et al.; YADERNAYA FIZIKA, Vol 48 No 5 (11), Nov 88]   | 12 |
| Scanning Tunnel Microscopy for Photosynthetic Reaction Centers<br>[S. D. Alekperov, S. I. Vasilyev; DOKLADY AKADEMII NAUK SSSR, Vol 303 No 2, Nov 88]  | 13 |

|  |    |
|--|----|
| Level Schemes and Binding Energy of Heavy Nuclei in Simplified Model With Greatly Restricted Dynamics<br>[L. Yu. Sabaliauskas, V. V. Vanagas, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, Vol 52 No 5, May 88]                    | 13 |
| Energy Dependence of Asymmetry Parameters of $\beta$ -Decay of Free Polarized Neutron With Allowance for Antineutrino Mass<br>[B. K. Kerimov, N. V. Samsonenko, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, Vol 52 No 5, Nov 88]  | 13 |
| Search for Monopole Nuclear Excitation During Decay of Bound Muon<br>[V. M. Abazov, N. A. Voinova-Yeliseyeva, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, Vol 52 No 5, Nov 88]  | 14 |
| Analog of Michel Parameter in Neutrino (Antineutrino)-Electron Scattering<br>[Yu. A. Gnedov, Yu. I. Romanov; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, Vol 52 No 5, May 88]   | 14 |
| Ways To Minimize Effects Minimizing Possible Neutrino Oscillations<br>[E. Ye. Berlovich; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 94 No 10, Oct 88]   | 14 |
| New Mechanism of Particle Acceleration and Relativistic Analogue of Fermi-Ulam Model<br>[L. D. Pustynnikov; TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA, Vol 77 No 1, Oct 88]  | 15 |
| Theory of Radiation and Formation of Electron-Positron Pairs by Ultrahigh Energy Particles in Crystals With Incidence Angles Exceeding Lindhard Angle<br>[N. K. Zhevago; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 94 No 10, Oct 88] | 15 |
| Series Expansion With Respect to Trajectory and Momentum Perturbations in Theory of Radiative Instabilities of Relativistic Electron Beams<br>[A. T. Bogdanov, M. V. Kuzelez; PISMA V ZHURNAL TEKHNICHESKOY FIZIKI, 12 Aug 88]                   | 15 |
| Self-Similar Solution to Equations of Dissipative Converging Shock Wave<br>[A. B. Budko; PISMA V ZHURNAL TEKHNICHESKOY FIZIKI, 12 Aug 88]  | 16 |
| Tunneling During Decay and Fusion of Complex Nuclei<br>[V. M. Shilov, A. V. Tarakanov; YADERNAYA FIZIKA, Vol 48 No 1(7), Jul 88]   | 16 |
| Elastic Scattering of Negative Pions and Kaons by Protons With 43<br>[Yu. M. Antipov, V. A. Batarin, et al.; YADERNAYA FIZIKA, Vol 48 No 1 (7), Jul 88]  | 16 |
| Inclusive Characteristics of Negative Pions Produced in pC and pTa Interactions With Proton Momentum of 10 GeV/s<br>[V. G. Grishin, I. A. Ivanovskaya, et al.; YADERNAYA FIZIKA, Vol 48 No 1 (7), Jul 88]  | 16 |
| Production of W. Bosons in Strong Electromagnetic Field and Their Contribution to Radiative Shift of Electron Mass<br>[V. Ch. Zhukovskiy, A. V. Kurilin; YADERNAYA FIZIKA, Vol 48 No 1 (7), Jul 88]  | 17 |
| Nonrelativistic String [M. O. Katanayev; YADERNAYA FIZIKA, Vol 48 No 1 (7), Jul 88]  | 17 |
| Nonlinear Two-Proton Interactions in Strong Magnetic Field<br>[V. V. Skobelev, N. O. Khasayev; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, Vol 31 No 6, Jun 88]  | 17 |
| Structure of Topological Solitons in Skyrme's Model<br>[I. R. Kozhevnikov, Yu. P. Rybakov, et al.; TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA, Vol 75 No 3, Jun 88]   | 17 |

## Optics, Spectroscopy

|  |    |
|--|----|
| Anomalous Light Absorption by Microparticle<br>[G. N. Nikolayev; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, 10 Jan 89]  | 18 |
| Determination of Parameters of Heterophase Aqueous Media by Laser Spectroscopy of Raman Light Scattering<br>[S. M. Glushkov, I. M. Panchishin, et al.; DOKLADY AKADEMII NAUK SSSR, Vol 303 No 2, Nov 88] | 18 |
| Dialogue Approach to Solution of Inverse Problems in Processing and Interpretation of Spectroscopic Data<br>[D. V. Yudin, V. V. Gorchakov; ZHURNAL PRIKLADNOY SPEKTROSKOPII, Vol 49 No 4, Oct 88]        | 18 |
| Absolute Intensities of Bands in IR Spectra of Cu-Porphyrins<br>[L. L. Gladkov, G. D. Yegorova; ZHURNAL PRIKLADNOY SPEKTROSKOPII, Vol 49 No 4, Oct 88]   | 18 |
| Superradiation and Superluminescence in Optical Cavity and Self-Excitation in It<br>[A. V. Andreyev, O. Yu. Tokhomirov, et al.; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 94 No 9, Sep 88]   | 19 |
| Quantum Limitations of Response of Gravity Wave Detectors With Free Masses<br>[S. A. Tsplyayev; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, Vol 31 No 9, Sep 88]                                     | 19 |



|  |    |
|--|----|
| Scattering of X-rays by Weakly Rough Surfaces<br>[A. V. Vinogradov, N. N. Zorev, et al.; <i>ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , Vol 94 No 8, Aug 88]  | 19 |
| Additive Compounding of Electronic Excitations of Yb on Ho-ions<br>[T. M. Kozhan, V. V. Kuznetsova, et al.; <i>ZHURNAL PRIKLADNOY SPEKTROSKOPII</i> , Vol 49 No 2, Aug 88]   | 19 |
| New Type of Cutoff Filter for Far-Infrared Range of Spectrum<br>[V. G. Vereshchagin, V. V. Morozov; <i>ZHURNAL PRIKLADNOY SPEKTROSKOPII</i> , Vol 49 No 2, Aug 88]   | 20 |
| Inelastic Scattering of Light by Fractal Vibration Modes in Polymers<br>[V. A. Bagryanskiy, V. K. Malinovskiy, et al.; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 8, Aug 88]  | 20 |
| Study of Collisional Mixing of B <sup>3</sup> Pi and A <sup>3</sup> Sigma States in Nitrogen Molecule by Method of Laser Fluorescence<br>[Yu. Z. Ionikh, N. P. Penkin, et al.; <i>OPTIKA I SPEKTROSKOPIYA</i> , Vol 65 No 1, Jul 88] | 20 |
| Characteristics of Stimulated Scattering in Low-Viscosity Fluids<br>[N. P. Malomuzh, S. B. Pelishenko; <i>OPTIKA I SPEKTROSKOPIYA</i> , Vol 65 No 1, Jul 88]   | 21 |
| Theory of Two-Stage Trough Formation in Spectrum by Light Pulses<br>[I. K. Rebane; <i>OPTIKA I SPEKTROSKOPIYA</i> , Vol 65 No 1, Jul 88]   | 21 |
| Formation of Prescribed Wavefront in Conjugate-Ring Laser Cavity<br>[V. V. Lyubimov, L. V. Nosova; <i>OPTIKA I SPEKTROSKOPIYA</i> , Vol 65 No 1, Jul 88]   | 21 |
| Synthesis of Images of Objects Viewed Through Randomly Nonhomogeneous Medium With Aid of Active Michelson Interferometer<br>[A. V. Anufriyev, A. L. Volpov, et al.; <i>OPTIKA I SPEKTROSKOPIYA</i> , Vol 65 No 1, Jul 88]            | 21 |
| Speckle Correlator for Measuring in Real Time Displacements of Rough Surface<br>[V. M. Dobrido, V. V. Manikalo, et al.; <i>OPTIKA I SPEKTROSKOPIYA</i> , Vol 65 No 1, Jul 88]  | 22 |
| Polarization of Laser-Excited Fluorescence<br>[V. P. Klochkov, A. G. Makogonenko; <i>OPTIKA I SPEKTROSKOPIYA</i> , Vol 65 No 1, Jul 88]  | 22 |
| Planar Waveguides With Singular Dispersion Law<br>[K. A. Landa, M. A. Igolinskaya, et al.; <i>PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI</i> , 12 Jul 88]   | 22 |
| Effect of Light Pressure on Processes in Plasma Produced by Laser Treatment<br>[G. A. Sheroziyah; <i>PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI</i> , 12 Jul 88]  | 22 |
| Parametric X-Ray Emission in Crystals Upon Passage of Ultrasonic Wave<br>[V. G. Baryshevskiy, I. V. Polikarpov; <i>ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , Vol 94 No 7, Jul 88]                                       | 23 |
| Ignition of Fuel Mixture by Flame Front Propagating Behind Shock Wave<br>[N. I. Mayorov, I. K. Fedoseyeva; <i>FIZIKA GORENIYA I VZRYVA</i> , Vol 24 No 3, May-Jun 88]  | 23 |

## Plasma Physics

|   |    |
|---|----|
| Influence of Radial Diffusion on Thermonuclear Yield in Tokamak<br>[F. S. Zaytsev, A. P. Smirnov, et al.; <i>FIZIKA PLAZMY</i> , Vol 15 No 1, Jan 89]   | 24 |
| Potential Scattering of Slow Electrons in Laser Radiation Field<br>[V. N. Pomerantsev, A. M. Popov, et al.; <i>FIZIKA PLAZMY</i> , Vol 15 No 1, Jan 89]   | 24 |
| Synthesis of Diamond by Dynamic Loading of Organic Matter<br>[V. F. Anisichkin, I. Yu. Malkov, et al.; <i>DOKLADY AKADEMII NAUK SSSR</i> , Vol 303 No 3, Nov 88]                                  | 24 |
| Electron Heating in Supercritical Shock Wave<br>[M. A. Balikhin, N. L. Borodkova; <i>FIZIKA PLAZMY</i> , Vol 14 No 11, Nov 88]  | 25 |
| Resonant Solitons of Electromagnetic Waves in Plasma With Admixture of Active Atoms<br>[I. V. Bachin, Timurkhuysay Nerguy; <i>FIZIKA PLAZMY</i> , Vol 14 No 11, Nov 88]                           | 25 |
| Dielectric Permittivity Perturbations Associated With Transformation of Electromagnetic Wave by Small-Scale Plasma Inhomogeneities<br>[V. V. Vaskov; <i>FIZIKA PLAZMY</i> , Vol 14 No 10, Oct 88] | 25 |
| Fine Structure of Front of Quasi-Perpendicular Supercritical Collisionless Shock Wave<br>[A. A. Galeev, V. V. Krasnoselskikh, et al.; <i>FIZIKA PLAZMY</i> , Vol 14 No 10, Oct 88]                | 25 |
| Dynamics of High-Current Pulse Discharge in Air<br>[Yu. K. Bobrov, V. V. Vikhrev, et al.; <i>FIZIKA PLAZMY</i> , Vol 14 No 10, Oct 88]  | 26 |
| Cooling of Positrons by Electrons<br>[A. S. Artamonov, Ya. S. Derbenev; <i>FIZIKA PLAZMY</i> , Vol 14 No 10, Oct 88]  | 26 |
| High-Temperature Acoustic Anomalies and Superionic Conductivity in Multicomponent Phosphate Glasses<br>[Yu. V. Ilisavskiy, L. A. Kulakova; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 10, Oct 88]    | 26 |

|   |    |
|---|----|
| Predicting Sensitivity of Explosive Substances to Impact<br>[A. V. Velik, V. A. Potemkin; <i>FIZIKA GORENIYA I VZRYVA</i> , Vol 24 No 5, Sep-Oct 88]  | 27 |
| Measurement of Parameters of Dense Plasma Produced by Impact Compression of Porous Tin and Copper<br>[L. G. Bolkhovitinov, Yu. B. Khvostov; <i>FIZIKA GORENIYA I VZRYVA</i> , Vol 24 No 5, Sep-Oct 88]                      | 27 |
| Strain Solitons in Nonlinearly Elastic Media Undergoing Phase Transition<br>[V. I. Serikov, S. V. Voronin; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 9, Sep 88]   | 27 |
| Characteristics of Drift Solitons in Plasma According to Results of Model Experiments With Fast-Rotating Shallow Water<br>[S. V. Antipov, M. V. Nezhlin, et al.; <i>FIZIKA PLAZMY</i> , Vol 14 No 9, Sep 88]                | 28 |
| Autotuning of Magnetic Antenna to Resonance by Plasma of High-Frequency Discharge<br>[G. A. Markov; <i>FIZIKA PLAZMY</i> , Vol 14 No 9, Sep 88]   | 28 |
| Mach Reflection of Conical Shock Waves in Condensed Medium<br>[A. Yu. Logvenov, A. L. Misonochnikov, et al.; <i>PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI</i> , 26 Aug 88]  | 28 |
| Alfvén Solitons and Shock Waves in Dissipative Plasma<br>[Dzh. I. Dzhavakhishvili; <i>FIZIKA PLAZMY</i> , Vol 14 No 7, Jul 88]  | 28 |
| Hypersonic Three-Dimensional Viscous Shock Layer at Blunt Body in Stream at Arbitrary Angle of Attack and Glancing Angle<br>[A. I. Borodin, S. V. Peygin; <i>TEPLOFIZIKA VYSOKIKH TEMPERATUR</i> , Vol 26 No 4, Jul-Aug 88] | 29 |
| Decay of Noncoherent Field in Ocean With Large-Scale Surface Roughness<br>[A. V. Belousov, Yu. P. Lysanov; <i>AKUSTICHESKIY ZHURNAL</i> , Vol 34 No 4, Jul-Aug 88]  | 29 |
| Fine Structure of Sound-Scattering Ocean Layers<br>[A. S. Borisov, V. S. Karpov; <i>AKUSTICHESKIY ZHURNAL</i> , Vol 34 No 4, Jul-Aug 88]  | 29 |
| Thermal and Dynamic Components of Short-Period Sound Velocity Fluctuations Near Ocean Surface<br>[A. S. Zapevalov, G. N. Khristoforov; <i>AKUSTICHESKIY ZHURNAL</i> , Vol 34 No 4, Jul-Aug 88]                              | 30 |
| Theoretical Study Concerning Depth Dependence of Oceanic Noise<br>[V. M. Serbin; <i>AKUSTICHESKIY ZHURNAL</i> , Vol 34 No 4, Jul-Aug 88]  | 30 |
| Level of Oceanic Noise Within Angular Range of Refraction Minimum<br>[A. V. Belousov, A. V. Furduev; <i>AKUSTICHESKIY ZHURNAL</i> , Vol 34 No 4, Jul-Aug 88]  | 30 |
| Exponential Profile of Shock Wave in Fluid<br>[Yu. V. Petukhov; <i>AKUSTICHESKIY ZHURNAL</i> , Vol 34 No 4, Jul-Aug 88]   | 30 |
| Radiation Emission by Excited Ar-Complexes and Kr-Complexes in Shock Waves<br>[N. D. Kurmey, V. G. Nazarenko; <i>FIZIKA GORENIYA I VZRYVA</i> , Vol 24 No 3, May-Jun 88]  | 31 |
| Study of Decomposition in Detonation Wave by Isotopic Method<br>[V. F. Anisichkin, B. G. Derendyayev, et al.; <i>FIZIKA GORENIYA I VZRYVA</i> , Vol 24 No 3, May-Jun 88]  | 31 |
| Possibility of Identifying Shock-Wave Processes<br>[Yu. N. Kuznetsov; <i>FIZIKA GORENIYA I VZRYVA</i> , Vol 24 No 3, May-Jun 88]  | 31 |

## Superconductivity

|  |    |
|--|----|
| Josephson Effect in Granulated Superconductors<br>[A. F. Volkov; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 25 Jan 89]  | 32 |
| Superconductivity at Temperatures Above 100 K in Bi-Ca-Sr-Cu-O System<br>[A. G. Sarkisyan, V. M. Arutyunyan; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 25 Jan 89]  | 32 |
| 'Ferroelectric' Anomalies and Superconductivity in Metallic Oxide Compounds<br>[A. S. Shcherbakov, M. I. Katsnelson; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 25 Jan 89]  | 32 |
| Spatial Distribution of Magnetic Induction Near Permanent Magnet and Attraction 'Effect' of High-Temperature Superconductor to Magnet Poles<br>[E. A. Vasilyev; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 25 Jan 89] | 32 |
| Resonance-Percolation Trajectories (RPT) as High-Temperature Superconducting Channels in Thin Films of Metallic Oxides<br>[V. Ya. Kurpichenkov; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 25 Jan 89]                 | 33 |
| Chemical Nature of Pairing of Holes in High-Temperature Superconductors<br>[I. Ye. Dzyaloshinskiy; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 25 Jan 89]  | 33 |

|   |    |
|---|----|
| Superconducting Helicoid: Alternative to Ordinary Superconducting Windings<br>[V. Ye. Keylin, I. A. Kovalev, et al.; <i>DOKLADY AKADEMII NAUK SSSR</i> , Vol 303 No 6, Dec 88]  | 33 |
| Influence of Infrared Radiation on Critical Current of Josephson Tunnel Junction<br>[S. V. Lempitskiy; <i>ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKA</i> , Vol 94 No 11, Nov 88]  | 34 |
| Inelastic Relaxation of Electrons in Superconductor-Normal Metal Microjunctions<br>[V. A. Khlus; <i>ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKA</i> , Vol 94 No 11, Nov 88]  | 34 |
| Polarization-Optical Contrast and Twin Domain Structure of Monocrystals of High-Temperature Superconductors<br>[D. Ye. Batova, V. K. Vlasko-Vlasov, et al.; <i>ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , Vol 94 No 11, Nov 88]                               | 34 |
| IR Reflection and Raman Light Scattering Spectra of Superconducting Compounds in Bi-Sr-Ca-Cu-O System<br>[O. V. Kosogov, M. V. Belousov, et al.; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 10 Nov 88]   | 34 |
| Possible Analogies Between Superconductor Perovskites and Superconductors With Heavy Fermions<br>[A. M. Tselik; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 10 Nov 88]  | 35 |
| New Data on Dependence of Critical Temperature on Oxygen Content in Superconducting Compound $YBa_2Cu_3O_x$<br>[I. V. Aleksandrov, A. B. Bykov, et al.; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 25 Oct 88]                                      | 35 |
| Energy Gap in $YBa_2Cu_3O_{7-x}$ Monocrystals With Different Oxygen Content<br>[A. P. Volodin, B. Ya. Kotyuzhanskiy, et al.; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 25 Oct 88]   | 35 |
| High-Temperature Superconductivity in Multiphase Ceramic Samples of Bi-Ca-Sr-Cu-O System<br>[A. G. Merzhanov, S. V. Lysikov, et al.; <i>PISMA V ZHURNAL TEKHNIЧЕСKOY FIZIKI</i> , 12 Oct 88]  | 36 |
| Superconducting Interference Magnetometers and Magnetic Screens From $YBa_2Ca_3O_7$ Ceramic Operating at Nitrogen Temperatures<br>[V. N. Zavaritskiy, N. V. Zavaritskiy; <i>PISMA V ZHURNAL TEKHNIЧЕСKOY FIZIKI</i> , 12 Oct 88]  | 36 |
| Structure of Phase $Y_1Ba_2Cu_3O_{6.5+y}$ and Superconductivity<br>[M. V. Krasinkova, B. Ya. Moyzhes; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 10, Oct 88]   | 36 |
| Research on Bolometric Properties of Films of Composition $Y-Ba_2Cu_{1-x}O_{7-x}$<br>[S. V. Gaponov, M. A. Kalyagin, et al.; <i>PISMA V ZHURNAL TEKHNIЧЕСKOY FIZIKI</i> , 26 Oct 88]  | 37 |
| Josephson Effect in Thin Films of High-Temperature Superconductors at 77 K<br>[A. I. Golovashkin, A. L. Gudkov, et al.; <i>PISMA V ZHURNAL TEKHNIЧЕСKOY FIZIKI</i> , 26 Jul 88]   | 37 |
| Detection of Thermal Radiation at Liquid-Nitrogen Temperatures With Bolometric Cells of Y-Ba-Cu-O High-Temperature Superconductor Thin Films on $SrTiO_3$ Substrate<br>[V. N. Alfeyev, A. S. Aleksandrov, et al.; <i>PISMA V ZHURNAL TEKHNIЧЕСKOY FIZIKI</i> , 26 Jul 88] | 37 |
| Emission of High-Energy Radiation in Alkali-Halogenide Crystals Upon Their High-Power Electron Bombardment in Pulses of Nanosecond Duration<br>[V. F. Pichugin, V. F. Stolyarenko; <i>PISMA V ZHURNAL TEKHNIЧЕСKOY FIZIKI</i> , 26 Jul 88]                                | 38 |
| Quantum Characteristics of Electromagnetic Effect in 123-Phase Y-Ba-Cu-O Ceramics<br>[V. F. Pichugin, V. F. Stolyarenko; <i>PISMA V ZHURNAL TEKHNIЧЕСKOY FIZIKI</i> , 26 Jul 88]  | 38 |
| Effect of Superconducting Transition on Luminescence Quantum Yield From Adsorbed Dye<br>[I. A. Yurchenko, V. Z. Lozovskiy, et al.; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 25 Jul 88]   | 38 |
| Fluctuations of Magnetization in $La_2CuO_{4-d}$ Structure<br>[V. Ye. Katayev, Ye. F. Kukovitskiy, et al.; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 25 Jul 88]   | 39 |
| Superconductivity of Semiconductor Superlattices on Lead Chalcogenides<br>[O. A. Mironov, B. A. Savitskiy, et al.; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 25 Jul 88]   | 39 |
| Macroscopic Theory of Superconductors With Small Coherence Length<br>[L. N. Bulayevskiy, V. L. Ginzburg, et al.; <i>ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , Vol 94 No 7, Jul 88]   | 39 |
| Superconductivity of Bi-Sr-Ca-Cu-O Bulk and Film Ceramics<br>[A. A. Sukhanov, Kh. R. Ozmanyanyan, et al.; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 10 Jul 88]  | 40 |



|  |    |
|--|----|
| Magnetic Characteristics of $\text{La}_2\text{CuO}_{4-x}$ Having $\text{La}^{3+}$ -ion Deficiency and Containing Magnetic Impurities<br>[A. N. Bazhin, V. N. Bevz; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 10 Jul 88]                                | 40 |
| Interaction of Superconductor Current and Moessbauer Radiation<br>[V. N. Belogurov, A. N. Borzyak, et al.; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 10 Jul 88]  | 40 |
| Hall Effect and Thermo-E.M.F. in $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ and $\text{HoBa}_2\text{Cu}_3\text{O}_{7-x}$ Single-Crystal Films<br>[A. I. Golovashkin, S. I. Krasnosvobodtsev, et al.; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 10 Jul 88] | 41 |
| Spectra of Raman Light Scattering in Bi-Sr-Ca-Cu-O High-Temperature Superconductors<br>[T. A. Fimberg, E.R. Ioon, et al.; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 10 Jul 88]   | 41 |
| Electronic Properties of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ System<br>[I. A. Garifullin, N. N. Garifyanov, et al.; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 10 Jul 88]   | 41 |
| Split of Superconducting Transition in High-Temperature Superconductors Owing Low Degree of Orthorhombicity<br>[G. Ye. Volovik; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 10 Jul 88]   | 42 |
| Magnetic Ordering in $\text{Y}_2\text{BaCuO}_5$ Compound<br>[N. I. Agladze, M. N. Popova, et al.; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 10 Jul 88]   | 42 |
| Superconducting Phases With Perovskitic Structure<br>[N. Ye. Alekseyevskiy, G. M. Kuzmicheva, et al.; <i>PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , 10 Jul 88]   | 42 |

## Thermodynamics

|  |    |
|--|----|
| Generation of Solitons and Bisolitons in Molecular Systems<br>[A. S. Davydov, V. N. Yermakov; <i>DOKLADY AKADEMII NAUK SSSR</i> , Vol 302 No 3, Sep 88]  | 43 |
| Comparative Analysis of Numerical Methods of Solving Integral Equations in Inverse Problems of Radiative Heat Transfer<br>[Ye. K. Belonogov, A. Yu. Zatsepin; <i>IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA TEKHNICHESKIKH NAUK</i> , Vol 15 No 4, Aug 88] | 43 |

## Theoretical Physics

|   |    |
|---|----|
| Once More About Ambiguity of Predictions of General Relativity Theory<br>[A. A. Logunov, Yu. M. Loskutov; <i>TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA</i> , Vol 76 No 2, Aug 88] | 44 |
| Exact Solutions in Relativistic Gravitation Theory<br>[K. A. Bronnikov, G. N. Shikin; <i>TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA</i> , Vol 76 No 2, Aug 88]                     | 44 |

## Numerical Analysis, Algorithms

|  |    |
|--|----|
| Holonomic Systems With Regular Singularities and Wavefronts of Feynman Integrals<br>[A. I. Zaslavskiy; <i>FUNKTSIONALNYY ANALIZ</i> ; Vol 22 No 3, Jul-Sep 88] | 45 |
|--|----|

## Probability, Statistics

|  |    |
|--|----|
| Optimization of Algorithm of Extremum Search by Complex Method<br>[V. S. Levshanov; <i>ZAVODSKAYA LABORATORIYA</i> , Vol 54 No 10, Oct 88] | 46 |
|--|----|

## Differential Equations

|  |    |
|--|----|
| Multisoliton Components of Solutions of Nonlinear Schrodinger Equation With Perturbing Term<br>[V. A. Vysloukh, I. V. Cherednik; <i>TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA</i> , Vol 78 No 1, Jan 89] | 47 |
| Stark Effect for Schrodinger Difference Operator<br>[Ye. I. Dinaburg; <i>TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA</i> , Vol 78 No 1, Jan 89]  | 47 |



|   |    |
|---|----|
| Nonlinear Theory of Flame Front Instability<br>[S. K. Zhdanov, B. A. Trubnikov; <i>ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> ,<br>Vol 95 No 1, Jan 89] .....   | 47 |
| One Inverse Problem in Formation of Coherent Radiation<br>[A. V. Goncharskiy, V. V. Stepanov; <i>DOKLADY AKADEMII NAUK SSSR</i> , Vol 303 No 2, Nov 88] .....   | 47 |
| New Results in Localization of Solutions of Nonlinear Elliptical and Parabolic Equations Derived by<br>Energy Method<br>S. N. Antontsev, J. I. Diaz; <i>DOKLADY AKADEMII NAUK SSSR</i> , Vol 303 No 3, Nov 88] .....                      | 48 |
| Singularly Perturbed Systems of Ordinary Differential Equations in Cases When 'Degenerate' Systems<br>Have Discontinuous Solutions<br>[M. I. Imanaliyev, P. S. Pankov; <i>DOKLADY AKADEMII NAUK SSSR</i> , Vol 303 No 3, Nov 88] .....    | 48 |
| Nominal Invariance and Precise Solutions of Nonlinear Equation of Acoustics<br>[V. I. Fushchich, N. I. Serov; <i>DOKLADY AKADEMII NAUK UKRAINSKOY SSR: SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNIЧЕСKIYE NAUKI</i> , No 10, Oct 88] ..... | 48 |
| Finite-Zone Solutions of Stationary Axisymmetric Einstein Equation in Vacuum<br>[D. A. Korotkin; <i>TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA</i> , Vol 77 No 1, Oct 88] .....  | 48 |
| Solution to Linear Equations in Spaces of Harmonic Variables<br>[I. A. Bandos; <i>TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA</i> , Vol 76 No 2, Aug 88] .....  | 49 |
| Analysis of Nonlinear One-Dimensional Systems by Hamiltonian Formalism<br>[V. G. Mikhalev; <i>TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA</i> , Vol 76 No 2, Aug 88] .....  | 49 |
| Asymptotic-in-Time Solution to Cauchy Problem for Landau-Lifshitz Equation<br>[R. F. Bikbayev, A. R. Is-s; <i>TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA</i> ,<br>Vol 76 No 1, Jul 88] .....   | 49 |
| Quasi-Periodic Solutions to Second-Order Ordinary Differential Equations<br>[Zh. Sartabanov; <i>IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR: SERIYA FIZIKO</i><br><i>-MATEMATICHESKAYA</i> , No 3, May-Jun 88] .....                           | 49 |
| Differential Equations on Complex Analytic Manifolds and Maslov's Canonical Operator<br>[B. Yu. Sternin, V. Ye. Shatalov; <i>USPEKHI MATEMATICHESKIKH NAUK</i> , Vol 43 No 3 (261),<br>May-Jun 88] .....                                  | 50 |

**Stability of Plane Nonlinear Waves in Smoothly Inhomogeneous Random Media**

18620078a Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 11, Nov 88 (manuscript  
received 24 May 88) pp 105-118

[Article by Ye. S. Benilov, Oceanology Institute imeni P.  
P. Shirshov, USSR Academy of Sciences]

[Abstract] A study was made of the stability of plane stationary waves in inhomogeneous media relative to three-dimensional disturbances. As a very typical and important example the study is centered on a long solitary wave propagating along the surface of an ideal fluid over an uneven bottom. The instability of a wave caused by parametric resonance between curved disturbances of its front and "collisions" with bottom irregularities is demonstrated. A factor limiting instability is the return radiation of unstable disturbances by a soliton so that solitary waves of quite small amplitudes are stabilized. The increment of disturbances and the shape of the neutral stability curve are computed. A theory developed for solitary waves in water is generalized at the qualitative level for arbitrary media and wave solutions of four types: 1) solitons, 2) periodic waves, 3) Burgers shock waves with a continuous profile, 4) gas-dynamic shock waves. The examination is limited to waves stable in the absence of inhomogeneities. Wave solutions of the second and fourth types are evidently unstable in any medium with random or periodic smooth inhomogeneities. Solitons and Burgers shock waves, as in the case of solitons in water, are unstable only in some range of their amplitudes. Figures 3; references 22: 18 Russian, 4 Western.

**Description of Elastic-Plastic Characteristics of Materials Loaded by Shock Waves from Kinetic Standpoint**

18620033b Novosibirsk FIZIKA GORENIYA I  
VZRYVA in Russian Vol 24 No 4, Jul-Aug 88  
(manuscript received 23 Jun 86) pp 109-114

[Article by A. I. Vorobyev, A. A. Gornovoy, and S. A. Novikov, Moscow and Chelyabinsk]

[Abstract] Equations of state including the kinetics of elastic and plastic strains as well as of local stresses are derived for metals under a dynamic load in the form of shock waves. Into account are taken the corresponding anharmonic collective thermal fluctuation within gaseous dilatons comparable to "hot spots" and their explosive decay with attendant multiplication of glissile dislocations. The temperature dependence of the amplitude of pressure which precedes yield corresponding to elastic-to-plastic transition and the dependence of the structural parameter in the Weibull function on that pressure amplitude are calculated on the basis of this model for Armco iron as well as for several plain carbon steels and alloy steels on this basis is also

calculated, for copper and aluminum, the pressure dependence of the stress which corresponds to reverse plastic-to-elastic transition. The results of these theoretical calculations are compared with experimental data, including those on the depthwise decay of the yield-preceding pressure wave. Figures 5; tables 1; references 13: 10 Russian, 3 Western.

**Shock Method of Synthesizing Cubic ZrO<sub>2</sub> Modification**

18620033c Novosibirsk FIZIKA GORENIYA I  
VZRYVA in Russian Vol 24 No 4, Jul-Aug 88  
(manuscript received 4 Jul 86, after completion  
16 Dec 86) pp 132-133

[Article by S. S. Batsanov, D. L. Guryev, and L. I. Kopaneva, Mendeleyevo]

[Abstract] Interaction of metal and water during compression of the metal-in-water suspension by a shock wave was studied in an experiment with a Zr suspension in water, passage of a 60 GPa shock wave through the suspension being followed by ejection of the reaction product into free space so that both temperature and pressure could return to their normal levels. The product, cubic ZrO<sub>2</sub> known to be thermodynamically stable at temperatures above 1300 K under high pressure and above 2000 K under normal pressure, was evidently synthesized within a time not longer than 0.01 ms with the residual temperature not exceeding 40 deg C. References 4: 2 Russian, 2 Western.

UDC 519.63:533.6.011.72

**Modeling Interaction of Shock Waves and Gas Inhomogeneities**

18620034a Leningrad ZHURNAL TEKHNIЧЕСКОЙ  
FIZIKI in Russian Vol 58 No 7, Jul 88 (manuscript  
received 28 Apr 87) pp 1259-1267

[Article by P. A. Voynovich, A. I. Zhmakin and A. A. Fursenko, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] Interaction of a shock wave and inhomogeneities in a gaseous medium is modeled, without specific geometrical formulation of the problem, for numerical analysis of the resulting flow pattern and its evolution with implied applicability of similarity laws. First is considered propagation of a plane shock wave through an ideal gas, a nonviscous and thermally nonconducting one, with a discretely nonuniform temperature distribution. The shock wave is assumed to propagate in cold gas along an impermeable straight boundary of a hot region. The simple problem of one such finitely wide region is followed by the more intricate problems of a plane shock wave propagating in a cold gaseous medium interspersed with hot layers alternately on both sides of the wave path. Next is considered propagation of a plane shock wave through gaseous media gasdynamically nonhomogeneous and not at thermodynamic equilibrium, specifically past a cylindrical region of a fast relaxing gas amid a slowly relaxing one. This case is compared with the case of a cylindrical region of a chemically not reacting hot gas amid a reacting one. Figures 7; references 23: 15 Russian, 8 Western.

**New Mechanism of Current Instability in Narrow-Band Semiconductors**

18620079a Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 8, 25 Oct 88 (manuscript  
received 14 Jul 88, after revision 14 Sep 88) pp 422-425

[Article by A. A. Akopyan, S. S. Bolgov, V. K. Malyutenko and A. P. Savchenko, Semiconductors Institute, Ukrainian Academy of Sciences]

[Abstract] The literature describes only a single mechanism for formation of an N-shaped volt-ampere characteristic (VAC) accompanying the magnetoconcentration effect (MCE). This article describes a current instability effect in  $\text{Cd}_{0.2}\text{Hg}_{0.8}\text{Te}$  films in a case of an MCE in the temperature range 300-380 K when the volumetric generation and recombination of carriers is caused by Auger processes. The doubled amplitude of current oscillations in some cases attained 50 percent of the mean current flowing through the sample. Under these conditions the reason for the formation of an N-shaped VAC is a decrease in the rate of Auger generation of carriers with exhaustion of electron hole pairs. Since the presence of an impoverished region in which generation predominates is characteristic for the MCE and if it, not a narrow enriched layer determines the VAC of the sample, with the predominance of Auger generation in the exhausted region the VAC may have an N-shaped segment. With a well-developed MCE the sample is divided into two regions: with enrichment with electron-hole pairs, called the pinch layer, with a thickness much less than the bipolar diffusion length and adjacent to one of the sides of the sample, and a region of impoverishment, occupying the entire remaining part of the sample. Only the exhaustion region is examined, assuming that the rate of surface recombination is so great that the sample current is determined for the most part by the exhausted region. This new current instability mechanism, described in detail, can be used in studying processes of Auger generation of carriers and in developing active elements of powerful (up to 1 KW) generators of regular and noise oscillations operating at room and higher temperatures. Figure 1; references: 3 Russian.

UDC 537.312.82

**Two-Stage Photogeneration of Charge Carriers in Exciplexes**

18620064c Moscow DOKLADY AKADEMII NAUK  
SSSR in Russian Vol 302 No 4, Oct 88 (manuscript  
received 1 Jun 87) pp 839-841

[Article by N. G. Kuvshinskiy, V. M. Komko, Academician (UkSSR Academy of Sciences) I. I. Lyashko, N. G. Nakhodkin, and V. I. Strikha, Kiev State University imeni T. G. Shevchenko]

[Abstract] Photogeneration of charge carriers in exciplexes by dissociation of the latter is first analyzed theoretically, to explain the sensitization of carbazole-base semiconductor films by a dye such as rhodamine

6G so that the spectral range of the internal photoelectric effect in these films widens. The mechanism of this process is tracked from the instant a dye molecule in the ground state  $^1\text{B}_0$  transfers to the excited state  $^1\text{B}_1$  upon absorption of a light quantum and then forms an exciplex upon interaction with the carbazole base, a donor in the ground state  $^1\text{D}_0$ . In an experimental study made for a more precise understanding of this mechanism, 0.001-0.005 mm thick films of PEPC (poly-N-epoxy propyl carbazole) plus 1 wt.pct rhodamine 6G sandwiched between an Al-electrode and a  $\text{SnO}_2$ -electrode were tested for photogeneration in the photoresistance mode with the Al-electrode at the positive potential and with the electric field intensity in the film exceeding  $3 \cdot 10^7$  V/m so as to ensure photocurrent saturation during treatment either with 630 nm radiation (absorption edge for rhodamine 6G from a 0.1-10 mW source alone or also with 540 nm radiation (absorption peak for rhodamine 6G) from a 0.04-4.5 mW source at the same time. Analysis and evaluation of the data on the basis of the updated Poole-Frenkel model indicate that this photogeneration process occurs in two stages. Figures 2; references 4: Russian.

UDC 540.273.171

**Research on Structure and Microhardness of Polycrystals of Cubic Boron Nitride**

18620111a Moscow VESTSI AKADEMII NAVUK  
BSSR: SERYYA FIZIKA- MATEMATYCHNYKH  
NAUK in Russian No 5, Sep-Oct 88 (manuscript  
received 6 Aug 87) pp 53-57

[Article by A. M. Mazurenko, A. A. Leusenko, V. M. Kuchinskiy and A. I. Olekhovich, Solid State Physics and Semiconductors Institute, Belorussian Academy of Sciences]

[Abstract] The results of research on the characteristics of formation of the structure of cubic boron nitride hemicrystals are given. It was found that with an increase in pressure and temperature the microhardness of the hemicrystals increases, which is attributable to a decrease in their granularity and an increase in the rate of the process of formation of  $\beta$ -boron nitride and the generation of microstresses. An increase in the heating time of the samples in the synthesis of hemicrystals of cubic boron nitride above that necessary for completing the  $\alpha \rightarrow \beta$  process of boron nitride transformation results in a worsening of their physicomechanical properties as a result of recrystallization and a decrease in microstresses. It is shown that it is possible to obtain cubic boron nitride hemicrystals with increased physicomechanical and cutting properties by a pressure increase up to 100 kbar or more during synthesis from graphitelike boron nitride. Figures 3; references 5: 3 Russian, 2 Western.

UDC 537.311.33

**Characteristics of Laser Action in Intrinsic Semiconductors During Electron-Beam Pumping**

18620035 Moscow IZVESTIYA AKADEMII NAUK  
SSSR: NEORGANICHESKIYE MATERIALY in  
Russian Vol 24 No 8, Aug 88 (manuscript received  
2 Sep 86) pp 1250-1258



[Article by I. V. Kryukova, Ye. V. Matveyenko and S. P. Prokofyeva, All-Union Scientific Research Institute of Optophysical Measurements]

[Abstract] An experimental study of intrinsic semiconductors, epitaxial GaAs, GaSb, InP, InAs, GaInAsP layers and lamellar CdS crystals, was made concerning laser action induced in them by electron-beam pumping. The GaAs and InAs layers with an electron concentration of  $(1.5-1.8) \cdot 10^{15} \text{ cm}^{-3}$  were grown from the gaseous phase on semiinsulating GaAs substrates. The GaSb and InP layers with an electron concentration of  $6 \cdot 10^{16} \text{ cm}^{-3}$  were grown from the liquid phase, solution-melt oversaturated with Ga or In respectively, on substrates of the same material. The GaInAsP layers were produced by heteroepitaxial growth from the liquid phase, oversaturated solution-melt, on InP substrates. The substrates were thermally etched at a temperature not higher than 500 deg C during the epitaxial process and coated with an epitaxial InP layer as buffer. The CdS crystals, with natural mirror facets and (1120) orientation, with an electron concentration of  $10^{14} \text{ cm}^{-3}$  and a residual impurity concentration not exceeding  $10^{15} \text{ cm}^{-3}$ , were grown from CdS powder by dynamic resublimation from the gaseous phase in an inert atmosphere. Such crystals were used for 0.5-0.6 mm long Fabry-Perot resonators. All specimens were transversely excited by pumping with a 50 keV electron beam, its electron concentration dropping to half the maximum level at a 0.35 mm radius, in pulses of 100 ns duration at a repetition rate of 50 Hz and with the current density varied over the 0.1-30 A/cm<sup>2</sup> range. Threshold as well as spectral and energy characteristics of these lasers were measured, including the temperature dependence of the internal radiation quantum yield and of the external differential quantum efficiency over the 80-300 K range, also the dependence of the maximum gain on the recombination rate pertaining to excess charge carriers. Figures 7; table 3; references 18: 10 Russian, 8 Western (1 in Russian translation).

**Radiation Emission by 4.4 GeV Electrons in Diamond, Silicon, and Germanium Single Crystals**  
18620030a Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 8, Aug 88 (manuscript  
received 22 Oct 87) pp 73-78

[Article by A. O. Aganyants, Yu. A. Vartanov, G. A. Vartapetyan, and V. B. Karibyan]

[Abstract] An experimental study of diamond, Si, and Ge single crystals was made, for an analysis of gamma radiation emitted by 4.4 GeV electrons passing through them

with the ratio of gamma-quantum energy to initial electron energy varying over the wide 0.005-0.94 range. The experiment was performed in the Yerevan synchrotron, the inner electron beam with a divergence of approximately  $5 \cdot 10^{-5}$  rad passing through a crystal. Coherent soft radiation in all crystals and noncoherent hard radiation in Si crystals was collimated within an angle of plus to minus  $1.5 \cdot 10^{-4}$  rad, the relative quantum yield of soft radiation being higher in diamond crystals than in Si and Ge crystals. Noncoherent hard radiation in diamond and Ge crystals was collimated within an angle of plus to minus  $5 \cdot 10^{-4}$  rad, its relative quantum yield also in Si crystals no being higher in aligned crystals than in randomly oriented ones with any collimation of the gamma-radiation. The fundamental frequency of emitted radiation was found to be the same in the crystals of all three elements and thus independent of the Z number, rather than being proportional to the square root of Z as has been suggested in earlier literature on this subject. Figures 6; references 8: 7 Russian, 1 Western.

UDC 535.34

**Temperature Dependence of  $A_2 \rightarrow T_2$  Transition Probability for  $\text{Cr}^{3+}$ -ions in Y-Sc-Ga Garnet Crystal**

18620039c Minsk ZHURNAL PRIKLADNOY  
SPEKTROSKOPII in Russian Vol 49 No 2, Aug 88  
(manuscript received 12 Jun 87) pp 296-299

[Article by M. A. Noginov, Yu. S. Privis, Z. S. Saidov, V. A. Smirnov, and I. A. Shcherbakov]

[Abstract] An experimental study of Y-Sc-Ga:Cr<sup>3+</sup> garnet crystals was made for a determination of the temperature dependence of the probability of electronic-vibrational  $A_2 \rightarrow T_2$  transition in the Cr<sup>3+</sup>-ions. Measurements made over the 77-500 K temperature range have yielded not only the integral absorption corresponding to the energy of the "effective" vibration which removes forbiddenness of d-transitions, also the half-width of the absorption band corresponding to  $A_2 \rightarrow T_2$  transition, the wavelength corresponding to maximum absorption within this band, and the absorption coefficient at this wavelength, but also the lifetime of the excited state ( ${}^4T_2, {}^2E$ ) of Cr<sup>3+</sup>-ions and the microparameter characterizing Cr-to-Er energy transfer in crystals also containing Er<sup>3+</sup>-ions. The authors thank S.P. Kalitin and A.L. Denisov for supplying Y-Sc-Ga:Cr and Y-Sc-Ga:Cr,Er crystals, and S.G. Semenov for assistance in setting up the experiment. Figures 1; references 13: Russian.



UDC 533.6

**New Class of Multidimensional Flow Patterns in Compressible Media Admitting Exact Linearization of Navier-Stokes Equations**

18620015 Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian No 3 (169), May-Jun 88 (manuscript received 27 Mar 87) pp 70-75

[Article by M. A. Demidov and A. P. Mikhaylov, Moscow]

[Abstract] Multidimensional flow of viscous compressible fluids with a density uniform in space and variable in time is considered, namely such a flow with pressure

peaking for which the Navier-Stokes equations reduce to linear elliptic Poisson equations. Analysis of such a flow is simplified by considering a potential flow so that integration of the Navier-Stokes equations reduces to solution of classical linear equations. The characteristics of all such fluids are determined from the corresponding equations of energy balance, which reduce to ordinary differential equations describing the specific volume as a function of time. For adiabatic flow of ideal fluids, "slow" flow with pressure peaking is shown to localize with shockless compression and formation of gasdynamic structures. The authors thank S. P. Kurdyumov and N. V. Zmitrenko for helpful discussions. References 15: Russian

**Features of Formation of Radiation of Nitrogen UV Laser Excited by Creeping Discharge**  
18620081a Leningrad PISMA V ZHURNAL  
TEKHNIЧЕСКОY FIZIKI in Russian  
Vol 14 No 20, 26 Oct 88 (manuscript received 27 Jul 88)  
pp 1856-1860

[Article by P. P. Brnzalov, B. O. Zikrin, N. V. Karlov and G. P. Kuzmin, General Physics Institute, USSR Academy of Sciences, Moscow]

[Abstract] The results of research on operation of a nitrogen UV laser (wavelength 337.1 nm) with different polarities of the voltage pulse feeding a creeping discharge are given. For example, a series of experiments was made to determine the energy distribution in the laser ray cross section in directions transverse and longitudinal to the plane of the creeping discharge for two pulse voltage polarities at a nitrogen pressure 18 mm Hg. It was found that the nature of energy distribution is not dependent on the polarity of the voltage pulse applied across the electrodes, being distinctly asymmetric in both longitudinal and transverse directions. The energy in the transverse direction is an intensive peak with a less strong wide wing. In the longitudinal direction the energy distribution is also essentially nonuniform near the initiating electrode. The electric field has a predominant direction along the normal to the discharge plane. Due to the asymmetric field distribution, with an increase in gas pressure in the range 300-400 mm Hg superluminescence is visually observed only near the electrode opposite the initiating electrode. The electrodes are therefore not indifferent to the polarity of the imparted voltage pulse. Figures 2; references: 9 Russian.

**Effect of Powerful Ultrashort Light Pulses on Matter**  
18620079b Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 8, 25 Oct 88, (manuscript received 11 Jul 88) pp 413-415

[Article by Ye. G. Gamaliy and V. T. Tikhonchuk, Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences]

[Abstract] Lasers have recently been developed which can generate powerful (more than  $10^{18}$  W/cm<sup>2</sup>) region 1  $\mu$ . The electric field strength of such a pulse is considerably greater than atomic, the energy of electron oscillations in the pulse field attains its rest energy and pulse duration is so short that the motion of matter in the course of its operation is insignificant. For these reasons the nature of the interaction between laser radiation and a target and the parameters of the forming plasma differ substantially from those well studied in the region of lower fluxes and nanosecond pulse durations. An analysis was therefore made of the processes of light absorption, heating and energy redistribution between electrons and ions for evaluating the parameters of the forming

plasma. Possible variants of its applications are examined. The processes transpiring under the influence of a powerful subpicosecond laser pulse on a condensed target are considered in detail. It is shown that under certain conditions a new nonhydrodynamic regime of interaction between radiation and matter arises. Under such conditions the plasma can serve as a source of a powerful pulse of hard x-radiation. The possibility of generation of high-energy electrons and ions and hard x-radiation makes it possible to regard the plasma generated under the influence of powerful ultrashort pulses on a condensed target as a new and interesting research field. References 7: 5 Russian, 2 Western.

UDC 533.09:621.378.3

**Possibility of Laser Sounding of Shock-Compressed Plasma (SCP)**  
18620093a Minsk ZHURNAL PRIKLADNOY  
SPEKTROSKOPII in Russian Vol 49 No 4, Oct 88  
(manuscript received 13 Feb 87) pp 558-562

[Article by M. A. Sultanov]

[Abstract] The laser method can be used in determining the optical characteristics of shock-compressed plasma (SCP). In a 1981 monograph on SCP the author demonstrated that SCP is one of the varieties of dense, relatively high-temperature plasma which can be obtained by powerful, short (up to 1 cm), pulsed discharges (PPD) by applying the fundamental principles of gas hydrodynamics. This necessitates research on the optical properties and spectroscopic characteristics of such an energy source, especially optical thickness, absorption coefficients, etc., but virtually no work has been done along these lines. The first attempt was therefore made to ascertain the absorptivity of a SCP formed in an inter-electrode gap by laser sounding (the SCP spectrum is characterized by strong discrete and continuous radiations). The circuitry and optical system of the experimental apparatus are illustrated. The sounding ray was generated by a ruby laser; measurements were made at atmospheric pressure. It is shown that this type of plasma absorbs about 80% of the transmitted radiation. The SCP is dense and in its emissivity is close to the emission of an ideally black body. Figures 2; references: 10 Russian.

UDC 535.341:621.375.826

**Optoacoustic Absorption Spectra of Ethanol, Acetone and Benzine**  
18620093b Minsk ZHURNAL PRIKLADNOY  
SPEKTROSKOPII in Russian Vol 49 No 4, Oct 88  
(manuscript received 21 Aug 87) pp 664-667

[Article by L. S. Vasilenko, N. M. Dyuba and A. A. Kovalev]

[Abstract] The optoacoustic method for the detection of microimpurities in atmospheric air has a high sensitivity. The use of a tunable CO<sub>2</sub> laser makes it possible to

hope for adequate selectivity in detecting such complex organic substances as ethanol in the analysis of air samples containing acetone or benzene. An optoacoustic detector was used in study of absorption by ethanol, acetone and benzene vapors in a nitrogen atmosphere in the region of generation of a  $\text{CO}_2$  laser. The measurements were made using a small  $\text{CO}_2$  laser. The principal advantages of the used optoacoustic detector is insensitivity to the background from the windows, including to absorption by the matter adsorbed on them and the possibility of sample pumping. The minimal absorption coefficient is readily determined. Ethanol has an absorption band caused by oscillation of the C-O bond falling in the laser generation band  $00^{\circ}1 - 02^{\circ}0$ . Acetone and benzene do not have an absorption band here. Figures 2; references 3: 2 Russian, 1 Western.

**Analogue of Ultrashort-Pulse Laser in Radio Frequency Range**

18620094c Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian

Vol 14 No 19, 12 Oct 88 (manuscript received 6 Jan 88, after revision 5 Sep 88) pp 1776-1779

[Article by M. N. Nersisyan and P. S. Pogosyan, Physical Research Institute, Armenian Academy of Sciences, Ash-tarak]

[Abstract] A report is given on the shaping of coherent ultrashort pulses in the millimeter wavelength range using the Cerenkov mechanism of interaction between laser radiation and a nonlinear medium. A picosecond glass-neodymium laser was used. The laser radiation was a train of pulses with a total duration of about 500 ns, an energy of 20 mJ and a pulse interval of about 7 ns. Cerenkov radiation was excited in a platelet of lithium niobate crystal. The polarization of the incident radiation and the optical axis of the crystal were in the plane parallel to the platelet surface. The research demonstrated that the Cerenkov interaction mechanism makes it possible to obtain an analogue of an ultrashort-pulse laser operating in the microwave range. Despite the small conversion efficiency, the creation of such sources is of interest not only for investigating the characteristics of ultrashort pulses but also for finding a number of other applications, such as spectroscopy of a solid body, investigation of the dynamics of destruction of the energy gap in superconductors, etc. Important new information was obtained in the IR and UV spectral regions where it is impossible to use the electrooptical stroboscopy method due to the lack of appropriate instrumentation. Figure 1; references 4: 3 Russian, 1 Western.

UDC 621.373.826.824:535.33

**Spectral Characteristics of Radiation of Flash-Lamp Dye Lasers With Selection of Generation Wavelengths by Phase Polarization Method**

18620099b Minsk ZHURNAL PRIKLADNOY  
SPEKTROSKOPII in Russian Vol 49 No 3, Sep 88  
(manuscript received 20 Jul 87) pp 417-423

[Article by A. P. Voytovich, L. P. Runets and A. Ya. Smirnov]

[Abstract] An experimental study was made of the conditions for control of the spectrum of generation of

flash-lamp dye lasers by the phase polarization method. A rhodamine 6G dye laser gave a narrowing of the spectrum to one longitudinal mode with its referencing to the absorption lines of the sodium and neon doublet in the range 585-598 nm. The width of the generation line, referenced to the center of the absorption contour, can be changed by a magnetic field in the range  $10^{-5}$ - $10^{-3}$  nm. The possibility of obtaining tunable two-wavelength narrow-band generation in the region of the contours of the selected absorption lines of matter is demonstrated. It is shown that computation of the spectral emission lines of such lasers with a high degree of accuracy is possible by the Jones matrices method in a threshold approximation. The efficiency of control of the spectrum of laser radiation in pulsed and stationary generation modes by this method is compared. The possibilities of the phase polarization method for selecting wavelengths in the described lasers have by no means been exhausted and can be extended to other types of lasers. Figures 3; references 8: 7 Russian, 1 Western.

**Anomalies in Reflection of Surface Electric Waves by Metal Surfaces With Periodic Profile Upon Resonant Excitation of Such Waves on Such Surfaces by Laser Beams in Pulses of Finite Duration**

18620051a Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 15, 12 Aug 88 (manuscript received 5 Apr 88)  
pp 1371-1375

[Article by A. N. Dolgina, A. A. Kovalev, and P. S. Kondratenko, All-Union Scientific Research Institute of Optophysical Measurements]

[Abstract] Resonant excitation of surface electric waves on metal surfaces with periodic profile by laser beams in pulses of finite duration is considered, assuming such a wave to be a plane monochromatic one and the surface profile to be a sinusoidal one. It is demonstrated theoretically that, when either the duration of the laser pulse is much shorter than the mean life of the waves or the radius of the laser beam is much smaller than the mean free path for the waves but much larger than the wavelength, no appreciable attenuation of the waves upon their specular reflection by the surface will occur even under optimum conditions. The problem of reflection and scattering is formulated for surface electric waves excited in the first diffraction order. It is analyzed and solved for the two extreme and most interesting theoretical cases of an infinitely wide laser beam and an infinitely long laser pulse duration. References 4: 1 Russian, 3 Western.

**Diagnostic Laser Apparatus for Geophysical Experiments**

18620051b Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 15, 12 Aug 88 (manuscript received  
12 Jan 88) pp 1379-1383

[Article by I. V. Moskalenko, L. Kh. Palmiste, Yu. K. Protzenko, K. Yu. Saar, A. Kh. Vyali, E. A. Urbanik, and D. A. Shcheglov]

[Abstract] A diagnostic laser apparatus has been designed and built for laser fluoroscopy during geophys-



ical experiments such as cloud seeding in the upper atmosphere, this apparatus being analogous to ones being used for study of plasma-surface interaction during laboratory experiments. It consists of a tunable dye laser pumped by a XeCl-laser, and a "Maison-1A" reflecting telescope with 800 mm focal length and 1:3.6 magnification for collection of scattered laser radiation, also measuring and recording instruments which include a radiation monitor and an 84-5 photomultiplier with necessary electronics. The apparatus has been so far tested on barium as cloud-seeding element. The excimer laser emitted pulses of 60 mJ energy with He in the active mixture and of 100 mJ energy with Ne in the active mixture, the pulse duration being 12-15 ns in each case. Measurements were made with apparatus airborne and operating like a lidar, with monostatic probing in the backscattering configuration. The authors thank O. F. Klyuyev, scientist in charge of the cloud-seeding expedition, and his team for their experimental work. Figures 2; references 7: 6 Russian, 1 Western.

#### **Relativistic Cherenkov Generator of Millimetric-Wave Radiation With ROD Resonator**

18620051c Leningrad PISMA V ZHURNAL

TEKHNIЧЕСКОY FIZIKI in Russian

Vol 14 No 15, 12 Aug 88 (manuscript received 21 Mar 88) pp 1425-1428

[Article by N. I. Gunina, S. D. Korovich, S. D. Polevin, A. M. Roytman, and V. Ya. Khristenko, Institute of High-Current Electronics, Siberian Department, USSR Academy of Sciences, Tomsk]

[Abstract] Two millimetric-wave (4 mm and 8 mm) Cherenkov oscillators with a corrugated rod serving as both resonator and retarding structure were tested in the Sinus-6-L high-current electron accelerator (Institute of Problems in Physics, USSR Academy of Sciences, Gorkiy), a beam of up to 700 keV electrons being formed in pulses of 25 ns duration and carrying a current of up to 8 kA. The electron beam was generated in a coaxial vacuum diode with a sparking cathode and transported in a strong magnetic field of a pulsed solenoid along the rod to a collector. The electron beam excited surface waves propagating along the rod, these waves being then converted by a conical stub into volume waves and the latter radiating through a vacuum window into the atmosphere. The intensity of the transporting magnetic field was varied over the 1-30 kOe range, the oscillator power remaining constant over the 10-30 kOe range and dropping in a weaker magnetic field on account of a less efficient electron beam transport. Both oscillators generated microwave pulses of 10-15 ns duration. The dependence of the oscillator power on the beam current and of the oscillator efficiency on the electron energy was found to be one with a peak corresponding to resonance. Maximum power and efficiency of the 4 mm oscillator were respectively 100 NW within the 6-8 kA range of beam current and 4 pct within the 500-600 keV range of electron energy. Maximum power and efficiency of the 8

mm oscillator were 150 MW and 6 pct within the same respective ranges of beam current and electron energy. Figures 2; references 6: 4 Russian, 2 Western.

#### **Transverse Channelling and Free-Electron Laser on Strong Standing**

18620009a Moscow ZHURNAL

EKSPERIMENTALNOY I TEORETICHESKOY

FIZIKI in Russian Vol 94 No 7, Jul 88 (manuscript received 7 Jul 87) pp 80-86

[Article by K. B. Oganessian, A. M. Prokhorov, and M. V. Fedorov]

[Abstract] A free-electron laser is described which involves interaction of the electron beam, a slightly relativistic one, and a strong standing electromagnetic wave as they cross each other with attendant transverse channelling of electrons on that wave between equiphase planes. The theory of such a laser is based on electron ballistic under these conditions. The channeling of an electron as well as its interaction with the electromagnetic field of a light wave resulting in fast and slow motions are analyzed, assuming that the electron is a relativistic classical one, whereupon the amplification of light is evaluated including the frequency characteristic of the gain. Numerical estimates indicate the feasibility of an infrared laser based on this principle. Figures 2; references 14: 1 Russian, 3 Western.

UDC 621.378.3

#### **Influence Of Collective Effects on Amplification in Locked Free-Electron Lasers**

18620011a Moscow FIZIKA PLAZMY in Russian

Vol 14 No 7, Jul 88 (manuscript received 9 Feb 87, after correction 11 Sep 87) pp 859-865

[Article by Bazylev and A. V. Tulupov, Institute of Atomic Energy imeni I. V. Kurchatov]

[Abstract] A new kind of free-electron laser with variable parameters is considered, a hot electron beam with a wide momentum spread passing once through resonance upon reflection by the ponderomotive potential and power saturation being avoided by locking the velocity of electrons with the phase velocity of the ponderomotive potential wave. The influence of Compton scattering and of Raman scattering on amplification of the laser wave are analyzed for nonlinearity of its dependence on the electron beam current. A uniform collisionless relativistic electron beam is assumed to propagate at a low angle in the plane of both counterpropagating pump wave and signal wave in a constant transverse magnetic field constituting a much stronger perturbation than the ponderomotive field and the space charge. The corresponding dispersion equation is derived from the wave equation for a nonlinear transverse current, with a correction to the distribution function according to the perturbation theory. The conditions for amplification are established, covering the small-gain linear range and



the large-gain range, whereupon the gain in both Compton and Raman modes of laser operation is evaluated. Analytical estimates indicated that the gain is less sensitive to the momentum spread of electrons than in a conventional free-electron laser and that departure from its linear dependence on the electron beam current occurs at much higher current density than in a laser without locking. References 6: 3 Russian, 3 Western (1 in Russian translation).

**Ruby Laser With Feedback Through Phase Conjugation by Stimulated Brillouin Scattering**

18620045a Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 13, 12 Jul 88 (manuscript received  
28 Feb 88) pp 1187-1190

[Article by A. A. Kovalev, L. V. Levashkevich, and V. G. Ignatyev, Institute of Electronics, BSSR Academy of Sciences]

[Abstract] Intracavity phase conjugation by stimulated Brillouin scattering is proposed as a method of producing an extremely narrow laser beam with only small diffractive divergence and loss modulation in high-energy pulses of nanosecond duration, this method having been tested on a ruby laser. The cavity was formed by glass plate with a 0.08 reflection coefficient and a plane exit mirror with a 0.50 reflection coefficient. The ruby crystal inside this cavity was beveled at a Brewster angle at both ends. An ethanol solution of No 1044 organic dye served as Q-switching medium. Corrective feedback through phase conjugation in early stages of radiation amplification and emission buildup was provided by an acetone cell forming a Brillouin mirror and, together with the exit mirror, a branch cavity for laser pulses focused on it by a lens. With the a proper distance between these two mirrors and the proper base length of the main cavity, pulses of up to 0.7 J energy and down to 4 ns duration were obtained at a repetition rate of 100 MHz in a beam with 0.5 mrad divergence. Figures 2; references 2: Russian.

**Selective Laser-Type Ion Source**

18620002c Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 12, 26 Jun 88 pp 1109-1111

[Article by G. D. Alkhazov, E. Ye. Berlovich, and V. N. Panteleyev]

[Abstract] Two variants of a laser-type ion source for mass-separators operating "on-line" with particle accelerators are described, such ion sources being eminently suitable for this application on account of the possibility of selectively ionize atoms of a specific element by multistage as resonant excitation into autoionization states. In the first variant atoms released in the target material by reaction of the later with fast charged particles and collected in a hot container are passed through a tube where they form an atom beam which then

becomes ionized upon crossing several pulsed laser beam. In the second variant, also suitable for mass-spectrometers, the very hot target material is bombarded with fast protons and the reaction products are passed through an electrically heatable tube made of a refractory metal for subsequent diffusion into the ion source through a hole in its back wall. The laser beam in this variant is a composite one formed by merger of three beams, each from a tunable dye laser at resonance with transitions in atoms of the given element and each pumped by a separate Cu-vapor laser in synchronism at a pulse repetition rate of 10 kHz. A major feature of this ion source is intense electron emission with attendant buildup of a potential difference along the wall, which prevents ions from reaching it and thus lowers the probability of recombination. Figures 1; references 2: 2 Russian, 1 Western.

UDC 621.375.4

**Hot-Hole Semiconductor Masers and Lasers**

18620008 Moscow VESTNIK AKADEMII NAUK SSR  
in Russian No 6, Jun 88 pp 3-8

[Article by A. A. Andronov, doctor of physical and mathematical sciences]

[Abstract] In the development of new hot-hole semiconductor masers and infrared lasers, which was begun at the Institute of Applied Physics (USSR Academy of Sciences), participate now not only the Institutes of Physics imeni P. N. Lebedev and of Engineering Physics imeni A. F. Ioffe (USSR Academy of Sciences) but also the Leningrad Polytechnic Institute imeni M. I. Kalinin and the Institute of Semiconductor Physics (LiSSR Academy of Sciences). These devices are to emit electromagnetic radiation within the 0.030-1.00 mm range of the spectrum between infrared and microwaves, solar radiation within this range not being able to reach the earth on account of its absorption by the atmosphere. In gyrotrons, masers operating at cyclotron resonance, the frequency of emitted radiation is determined by the angular velocity of a free electron in the magnetic field, this velocity depending on the intensity of that field and on the mass of such an electron. Electrons and holes in semiconductors have an effective mass which can be much smaller than that of a free electron so that microwave and infrared frequencies can be attained in much weaker magnetic fields. With this possibility as the starting point, and drawing heavily on the Monte Carlo method of numerical simulation, researchers have established the conditions for making lattice vibrations in a semiconductor crystal under an external voltage produce an inverted nonequilibrium charge carrier distribution. The principal process leading to stimulated microwave radiation or light emission here is cyclotron radiation emission by holes in a magnetic field, such a maser or laser being essentially a p-Ge bar crystal of centimetric size between current electrodes on opposite facets and inside a large superconducting solenoid, all placed in a liquid-helium "Dewar" cryostat. Such devices featuring

either wide-spectrum or narrow-line radiation emission over the 0.070-0.200 mm range have already been built, tunability of narrow-line radiation emission over this entire range being evidently feasible but yet having been achieved. So far narrow-line radiation emission was successfully tuned over the 0.100-0.150 mm range, also over both 0.200-0.350 mm and 0.800-4.00 mm ranges. Lasers operating at transitions between light and heavy holes emit pulses of 0.001-0.005 ns duration with a power of 1-10 W. Masers operating at cyclotron resonance for holes with negative mass emit pulses of up to

0.070 ms duration with a power of up to 10 W and masers operating at cyclotron resonance for light holes emit pulses of 0.001 ms duration with a power of 1-10 W. Subjects of further study include the feasibility of operating at liquid-nitrogen and thus higher than liquid-helium temperature, with either the crystal uniaxially compressed or Ge replaced by Si or an  $A^{III}B^V$  compound as active medium. The paper was discussed, after its presentation, by V. N. Murzin (Institute of Physics) and Academician A. M. Prokhorov. Figures 3; references 3: Russian.

UDC 621.181.7

**Temperature Regime of Heated Supercritical Pressure Channels Under Nonstationary Conditions**

18620105a Moscow *TEPLOFIZIKA VYSOKIKH TEMPERATUR* in Russian Vol 26 No 5, Sep-Oct 88  
(manuscript received 25 Nov 87) pp 932-939

[Article by I. I. Shmal, K. I. Soplenkov and V. S. Polonskiy, High Temperatures Institute, USSR Academy of Sciences]

[Abstract] A model is proposed for computing the temperature regime of a heated supercritical pressure channel in a steam generator based on a joint solution of the nonstationary equations of hydrodynamics and thermal

conductivity. Such research is necessary because with an increase in the parameters of the heat carrier there is also an increase in wall temperature of the heated channels which may reach the admissible limit. Under nonstationary conditions the heating surfaces may be considerably overheated, deteriorate or even be destroyed. A numerical study was therefore made of the temperature regime of pipes in a power plant with a great residual heat release accompanying the stoppage of the supply pump. The influence of nonuniformity of heat transfer over the length and perimeter of the channel was investigated. It was found that estimates of the temperature field on the basis of stationary solutions give rise to considerable errors and that the mass discharge of the heat carrier exerts a considerable influence on the temperature regime under emergency conditions. Figures 5; references 6: 5 Russian, 1 Western.

**Theory of Interaction of Solitons of Q-Ball Type**

18620113a Moscow ZHURNAL

EKSPERIMENTALNOY I TEORETICHESKOY

FIZIKI in Russian Vol 95 No 1, Jan 89 (manuscript

received 15 Apr 88) pp 13-23

[Article by T. I. Belova and A. Ye. Kudryavtsev, Institute of Theoretical and Experimental Physics]

[Abstract] The properties of solitons for scalar charged fields (in the article called "Q-balls," using the terminology introduced by S. Coleman) are discussed. The existence of classically stable solitons with a stipulated time dependence is known in classical theories of self-interacting charged fields. In this article, however, it is shown that there is a region of relative velocities in the collision of solitons in which their interaction is almost elastic. In particular, in the indicated region with the interaction of a soliton (S) and an antisoliton (A) annihilation is absent. Near  $v_{cr}$  there is a process of merging of two solitons into a single strongly excited soliton of the "breather" type, that is, the process  $S + S \rightarrow S^*$  is observed. The nature of the "breather" solution  $S^*$  is discussed. With a further decrease in collision velocity there can be an "explosion" of the solution, manifested in decay into the lower-lying vacuum state. Figures 8; references 16: 8 Russian, 8 Western.

**Multipole Electromagnetic Moments of Neutrinos in Dispersive Medium**

18620113b Moscow ZHURNAL

EKSPERIMENTALNOY I TEORETICHESKOY

FIZIKI in Russian Vol 95 No 1, Jan 89 (manuscript

received 9 Jun 88) pp 35-46

[Article by V. B. Semikoz and Ya. A. Smorodinskiy, Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences; Atomic Energy Institute imeni I. V. Kurchatov]

[Abstract] In a dispersive medium (DM) the electromagnetic interaction of neutrinos with particles and external electromagnetic fields increases sharply. Allowance for the electromagnetic structure of neutrinos in the medium becomes particularly important because the cross section of the electromagnetic channel of the reactions exceeds the Born cross section by many orders of magnitude. This means that in a DM, in contrast to a vacuum, the electromagnetic contributions to the cross sections of weak processes do not lead to small corrections. Their value is completely determined by the electromagnetic form factors of neutrinos in the medium. This article discusses the normalization of these form factors, determining the characteristic multipole electromagnetic moments of a particle. Four multipole moments of Dirac and Majorana neutrinos in a dispersive medium are computed: electrical monopole (charge), electrical dipole and anapole dipole moment. These same quantities in a vacuum are given as a comparison. In an isotropic medium the neutrinos have no (induced) anapole moment, but in a ferromagnetic

such a moment does appear, for Majorana neutrinos being the sole electromagnetic characteristic. The cross section of elastic scattering of Majorana neutrinos on nuclei in isotropic plasma is computed as an example. References 15: 10 Russian, 5 Western.

**Spin and Statistics of Solitons in Film of Superflowing  $^3\text{He-A}$**

18620091d Moscow PISMA V ZHURNAL

EKSPERIMENTALNOY I TEORETICHESKOY

FIZIKI in Russian Vol 49 No 1, 10 Jan 89 (manuscript

received 6 Dec 88) pp 55-57

[Article by G. Ye. Volovik, A. Solov'yev and V. M. Yakovenko, Theoretical Physics Institute imeni L. D. Landau, USSR Academy of Sciences] (txt)

[Abstract] In an earlier study (G. E. Volovik, PHYSICA SCRIPTA, 38, 321, 1988), in research on the spin and statistics of a soliton, it was demonstrated that in a  $^3\text{He-A}$  film, due to a combination of spin antiferromagnetism and orbital ferromagnetism, symmetry allows the existence of a term. However, computation of the value in that study was incorrect. In this study it is assumed that  $\epsilon = \pi n$ , where  $n$  is the number of energy transverse quantization levels in the film and may be even or odd, depending on the thickness of the film. In definite intervals of film thickness an elementary soliton is a fermion. Two methods are applied in examining the problem. One makes use of the correlation between the considered phenomenon and an analogue of the Hall quantum effect. The Hall current in the film and the anomalous spin current arising due to the term are interrelated, making it possible to express the parameter through Hall conductivity  $\sigma$ . With respect to the Fermi statistics of solitons a  $^3\text{He-A}$  film must not be unique. Such two-dimensional electron structures must be sought among magnetic media in which spin ferro- or antiferromagnetism is combined with orbital ferro- or antiferromagnetism in such a way that symmetry does not prohibit existence of a term. References 6: 1 Russian, 5 Western.

UDC 534.232:535.211

**Sound Amplification by Optical Radiation in Light-Absorbing Medium**

18620107c Moscow AKUSTICHESKIY ZHURNAL in

Russian Vol 35 No 1, Jan-Feb 89 (manuscript received

19 Jan 88) pp 76-79

[Article by A. I. A. Kolomenskiy, General Physics Institute, USSR Academy of Sciences]

[Abstract] The development of acoustic instability caused by the influence of sound on the optical absorption coefficient is described. General conditions are defined for realization of such sound amplification and several situations under which this effect can be registered experimentally are examined. This is illustrated for the case of propagation of a plane acoustic wave along the x-axis in a region with a distribution of light intensity



$I(x,t)$ . Two geometries are possible for experimental realization of this effect: 1) sound propagation is perpendicular to the axis of the light beam, with the size of the interaction region being determined by beam radius; 2) the acoustic and light beams are propagated in the same direction from the boundary of the medium, in which case the length of the interaction region is usually determined by the depth of penetration of optical radiation into the medium. These cases are examined in detail. The threshold intensity of light and the amplification factor are found. References 9: 7 Russian, 2 Western.

**Can Particles With Energies Greater Than  $4 \times 10^{17}$  eV Be Neutrals?**

18620092a Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 10, 25 Nov 88  
(manuscript received 13 Oct 88) pp 513-515

[Article by A. V. Glushkov, Space Physics Research and Aeronomy Institute, Siberian Department, USSR Academy of Sciences]

[Abstract] On the basis of a comprehensive analysis of many experiments with extensive atmospheric showers it is postulated that neutral particles may play an appreciable role in primary cosmic radiation. This article gives some new facts supporting this hypothesis. The research data included information on the arrival of 8776 individual showers. Particle densities were registered using two scintillation detectors each with an area of  $2 \text{ m}^2$ . The analysis included showers with zenith angles greater than  $60^\circ$ . The results were difficult to explain on the basis of the ordinary picture of propagation of charged particles in the galactic magnetic field. It is apparent that extragalactic radio sources play a definite role in the generation of such particles. Such a conclusion was drawn from a study of the coordinates of the directions of arrival of 330 showers with energies greater than  $10^{19}$  eV in the range of declinations  $17^\circ$ – $90^\circ$ . The pattern of directions of arrival of individual extensive atmospheric showers with energies greater than  $4 \times 10^{17}$  eV in equatorial coordinates has a small-scale structure which cannot be attributed to a random statistical distribution of initial data. This pattern may be associated with the position of point sources which generate neutral particles. Figure 1; references 6: 2 Russian, 4 Western

**Toroidal Excitons in Crystals**

18620092b PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 10, 25 Nov 88  
(manuscript received 17 Oct 88) pp 565-567

[Article by Yu. V. Kopayev and N. V. Korniyakov, Microelectronics Institute, USSR Academy of Sciences] (txt)

[Abstract] In addition to electrical and magnetic multipoles, there is a third independent family of electromagnetic multipoles—toroidal. It is shown that this family corresponds to a bound electron-hole state having a toroidal moment, a toroidal exciton. The wave function of this state changes sign with both spatial and temporal inversions. It is demonstrated that the density of the toroidal moment is non-zero for states characterized by a purely imaginary spatially antisymmetric wave function.

The selection rules for transitions into toroidal exciton states differ substantially from the selection rules for transitions into exciton states of a different symmetry, affording a good possibility for the experimental detection and identification of toroidal excitons in crystals. Figures 2; references; 5 Russian.

**Expanded Translational Symmetry in Theory of Multisublattice Magnetics, Spin Waves, Phase Transitions, Domain Walls and Antiferromagnetics of  $UX_n$  Type**

18620078b Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 11, Nov 88 (manuscript received 3 Mar 88) pp 194-207

[Article by A. L. Alistratov and D. A. Yablonskiy, Donetsk Physical Technical Institute, Ukrainian Academy of Sciences]

[Abstract] A new method is proposed for a theoretical analysis of multisublattice magnetics. In definite cases the method makes it possible within the framework of a precise mathematical procedure to effectively reduce the number of magnetic sublattices and thereby considerably simplify the construction of both a linear and a nonlinear theory of spin waves. The possibilities of the method are illustrated by computation of the spectrum of magnons and the frequencies of antiferromagnetic resonance in  $\text{MnCl}_4(\text{NH}_3)_2(\text{CH}_3)_3$  and in the cubic phase of uranium compounds of the  $UX_n$  type. A criterion for the degeneration of the spectrum of magnons over the entire surface of the Brillouin zone is formulated. In all the considered examples the magnetically ordered crystals were described by model Hamiltonians of a quite general form. It was possible to reduce four-sublattice antiferromagnetics to single-sublattice systems. This graphically demonstrates the possibilities of the extended translational symmetry method. Figures 2; references 29: 16 Russian, 13 Western.

**Analysis of Data on High-Energy Muons in Extensive Atmospheric Showers**

18620083 YADERNAYA FIZIKA in Russian  
Vol 48 No 5 (11), Nov 88 (manuscript received 28 Jan 88) pp 1349-1356

[Article by V. V. Vashkevich, P. F. Yermolov, N. N. Kalmykov, M. V. Motova, S. S. Ostapchenko, B. A. Khrenov and G. B. Khristiansen, Nuclear Physics Scientific Research Institute, Moscow State University]

[Abstract] An earlier article by V. V. Vashkevich, et al. (YADERNAYA FIZIKA, Vol 47, p 1054, 1988) gave the results of an experimental study of the muon component of extensive atmospheric showers made using an underground magnetic spectrometer. These results included information on the energy spectrum of muons, their spatial distribution, the ratio of the number of positively charged muons to the number of negatively charged muons and the dependence of the total number of muons

with different threshold energies on the number of electrons in extensive atmospheric showers. The totality of these data makes it possible to check the reliability of the used models of nuclear interaction in the energy range  $10^6$ - $3 \times 10^7$  GeV and the postulated nuclear composition of primary radiation in this same energy range. This article gives a comparison of the results of computation of the enumerated characteristics of the muon component of extensive atmospheric showers and the experimental results given in the earlier article. The Kaydalov-Ter-Martirosyan quark-gluon strings model is used as the base model of nuclear interaction at high energies. The spatial distribution of muons in the entire studied range of threshold energies of muons agrees with the predictions of the quark-gluon strings model on the assumption of a constancy or weak increase in the mean transverse momentum of secondary particles in the range of primary energies  $10^3$ - $10^7$  GeV. The experimental dependence of the mean number of muons with a threshold energy more than or equal to 100 GeV on the number of electrons in extensive atmospheric showers is explained in the quark-gluon strings model with allowance for a small change in the composition of primary cosmic radiation anticipated in a diffusion model of the origin of cosmic rays. In the region of primary energies the nuclear composition is light. Figures 6; references 20: 13 Russian, 7 Western.

UDC 539.21

#### Scanning Tunnel Microscopy for Photosynthetic Reaction Centers

18620077c Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 303 No 2, Nov 88 (manuscript received 18 Jul 88) pp 341-344

[Article by S. D. Alekperov, S. I. Vasilyev, A. A. Kononenko, Ye. P. Lukashov, V. I. Panov and A. E. Semenov, Moscow State University imeni M. V. Lomonosov]

[Abstract] The scanning tunnel microscopy (STM) method is effective in biological research due to its high resolution in both a deep vacuum and when using dielectric media between electrodes. The method does not require preliminary dehydration of biological samples, which can cause irreversible changes of their properties. With STM there is virtually no impairment of sample structure. The STM method was used in studying the photosynthetic reaction centers of purple bacteria. The objective was a determination of the optimal conditions for observing and obtaining STM images of reaction centers and the detection of regions of local structural changes with potential variations of the tunnel barrier and development of a method of controllable transfer of individual molecules and their clusters and their precipitation on a backing. The best studied reaction centers are those from *Rhodobacter sphaeroides* R-26. The method for preparing samples for STM research is described. The electrostatic attraction method was used for extracting individual biomolecules from the layer and their precipitation on the selected

sector of a pure backing for study of the reaction centers. The individual molecules were investigated at different potentials. The resulting image of reaction center molecules agrees well with data from x-ray structural analysis. With variations of tunnel barrier potential the reaction center images reveal regions of local structural changes, evidently indicating presence of conductivity channels or presence of an excess dipole electric moment. A number of mechanisms for conductivity of a reaction center molecule are postulated. Whether the most probable mechanisms operate separately or jointly has not yet been determined. Figures 2; references 14: 3 Russian, 3 Western.

UDC 539.142

#### Level Schemes and Binding Energy of Heavy Nuclei in Simplified Model With Greatly Restricted Dynamics

18620063a Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 52 No 5, May 88 pp 838-849

[Article by L. Yu. Sabaliauskas, V. V. Vanagas, T. V. Guseva, Ya. Kh. Ruza and Yu. Ya. Tamberg, Physics Institute, Lithuanian Academy of Sciences; Physics Institute, Latvian Academy of Sciences]

[Abstract] A simplified model with a highly restricted dynamics and effective quadrupole interaction was used in an earlier study in research on isobaric nuclei with a mass number  $A = 20$  (V. V. Vanagas, et al., LIT. FIZ. SB., Vol 22, No 6, 1982), but the problem of its applicability for heavy nuclei remained unexplored. For the first time a study is made of application of the simplified model with highly restricted dynamics for describing binding energy and some bands of excited states of heavy even-even and odd nuclei. A study was made of a general form of the Hamiltonian of a model with a highly restricted dynamics and a classification of states of heavy even-even and odd nuclei soluble using the Pauli principle with irreducible representations of symmetric  $S_A$  and special unitary  $SU_3$  groups is given, as well as expressions for the matrix elements of the Hamiltonian of the used model in the case of even-even and odd nuclei when quadrupole interaction is used as the potential. The article examines the computation method and the results of computations of binding energy and schemes of excited states of nuclei are presented. The results are evaluated and the prospects for describing the low-lying part of the spectra of heavy nuclei within the framework of models with limited dynamics are discussed. Figures 3; references 33: 15 Russian, 18 Western.

UDC 539.165

#### Energy Dependence of Asymmetry Parameters of $\beta$ -Decay of Free Polarized Neutron With Allowance for Antineutrino Mass

18620063b Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 52 No 5, May 88 pp 892-898

[Article by B. K. Kerimov, N. V. Samsonenko and Ch. L. Katkhat, Moscow State University imeni M. V. Lomonosov; University of Friendship of Peoples imeni P. Lumumba; Joint Institute of Nuclear Research]

[Abstract] This article is a further development of earlier studies by the authors (IZV. AN SSSR: SER. FIZ., Vol 50, 1986; Vol 51, 1987, and elsewhere). A study is made of different asymmetries of emission of an electron and antineutrino and also the triple correlation as a function of electron energy and antineutrino mass in the  $\beta$  decay of a free polarized neutron at rest. (The  $\beta$  decay of both unpolarized and polarized neutrons is examined.) An effort is made to detect new effects caused by the mass of antineutrinos. The following aspects of the problem are examined in addition to polarized free neutron beta decay: electron-antineutrino mass effects, electron longitudinal polarization, electron-antineutrino angular correlation, neutron spin-electron and neutron spin-antineutrino correlations, antineutrino mass determination and time-reversal invariance. Formulas are derived for the description of these and other pertinent phenomena. These are used, for example, in calculating the upper limit of the rest mass of an electron antineutrino (0.06 KeV). Figures 3; references 16: 10 Russian, 6 Western.

UDC 539.163

#### Search for Monopole Nuclear Excitation During Decay of Bound Muon

18620063c Moscow IZVESTIYA AKADEMII NAUK  
SSSR: SERIYA FIZICHESKAYA in Russian  
Vol 52 No 5, May 88 pp 1008-1014

[Article by V. M. Abazov, N. A. Voinova-Yeliseyeva, V. A. Gordeyev, S. A. Kutuzov, I. A. Mitropolskiy, Kh.-G. Orlepp, B. M. Sabirov and G. Ye. Solyakin, Leningrad Nuclear Physics Institute imeni B. P. Konstantinov; Nuclear Problems Laboratory, Joint Nuclear Research Institute]

[Abstract] The study of interaction of mesons with complex nuclei gives important results relating to the properties of nuclei and the fundamental laws of strong, weak and electromagnetic interactions. Two types of excitation of a nucleus in muon atoms are well known: excitation in the process of successive transitions of a muon and as a result of  $\pi^-$ -capture. This article gives a theoretical and experimental study of the possibility of a third type of nucleus excitation during decay of a bound muon. The detection of this new process and checking of the correctness of the concepts developed in this article may afford a new additional method for the study of nuclear monopolar states. The basis of an experiment for search for the excitation of a nucleus during decay of a bound muon is the registry of coincidences of electrons from  $\mu$ -decay with  $\gamma$ -quanta of nuclear transitions. The theoretical probabilities of excitation and the possibilities of conversion transitions make it possible to examine nuclei of the rare earth type as a target; the case examined was a  $^{152}\text{Sm}$  nucleus. The experimental MYEGA apparatus developed for the excitation of nuclei during decay of a bound muon is diagrammatically illustrated and described. In order to detect the process of excitation of the first  $O^+$  level of  $^{152}\text{Sm}$  with an error 10 percent it is necessary to have about 100 events, for

which approximately 200 hours of accumulation of statistics is required. The experimental data made it possible to ascertain the upper limit of probability of excitation of the first  $O^+$  level of  $^{152}\text{Sm}$  during the decay of a bound muon and suggest that further research along these lines is in order. Figures 6; references 11: 9 Russian, 2 Western.

UDC 539.17.01

#### Analog of Michel Parameter in Neutrino (Antineutrino)-Electron Scattering

18620063d Moscow IZVESTIYA AKADEMII NAUK  
SSSR: SERIYA FIZICHESKAYA in Russian  
Vol 52 No 5, May 88 pp 1015-1019

[Article by Yu. A. Gnedov and Yu. I. Romanov]

[Abstract] The results of past and planned investigations of elastic neutrino and antineutrino electron scattering, especially a study of the energy spectra and angular distributions of recoil electrons, can be a source of information on diagonal lepton processes. A detailed analysis of the different characteristics of these processes is assuming great importance since the publication of new data on observation of elastic scattering and a new formulation of an experiment on the scattering of reactor antineutrinos on an electron. Accordingly, a study was made of elastic neutrino (antineutrino)-electron scattering using a general form of a four-fermion Lagrangian corresponding to the product of the experimentally studied neutral currents of a neutrino and electron on the assumption that the electron neutral current has an arbitrary  $(V, A)$ -space-time structure. It was found that at the relativistic limit the ratio of the total cross sections of elastic neutrino- and antineutrino-electron scattering is determined by a combination of constants  $g_V$  and  $g_A$ . It is therefore postulated that the precise measurement of the total cross sections can serve as a sensitive method for studying the interference of neutral and charged currents in neutrino (antineutrino)-electron scattering. References 7: 3 Russian, 4 Western.

#### Ways To Minimize Effects Minimizing Possible Neutrino Oscillations

18620087a Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 9, 10 Nov 88 (manuscript  
received 4 Oct 88 pp 477-479)

[Article by E. Ye. Berlovich, Nuclear Physics Institute imeni B. P. Konstantinov, USSR Academy of Sciences]

[Abstract] Observation of neutrino oscillations would be of fundamental importance for understanding the nature of these particles and would provide unambiguous evidence that they have a rest mass. It is important to understand whether the failure in search for such oscillations in reactor and accelerator experiments is related to impairment of the conditions required for observation of the effect (defined in earlier research). A study was



made of the influence of the various factors making the observation of neutrino oscillations difficult in such experiments. A method is proposed for completely precluding the impairment of coherence caused by the continuity of the neutrino spectrum, at the same time minimizing the violation of other necessary conditions. The proposal involves an underground laboratory in which there would be a strong radioactive source whose nuclei, experiencing K-capture, emit monoenergetic neutrinos. A source  $^{65}\text{Zn}$ , due to its half-life, is most suitable for this purpose in the active zone of modern research reactors. Neutrinos with an energy 1.35 MeV would be emitted; with a sample mass 7 kg the activity could be close to 1 megacurie (the transpiring reactions are described). It is shown that the impairment of neutrino beam coherence could thereby be precluded and the other factors masking the oscillation effect could be minimized. Figure 1; references 6: 4 Russian, 2 Western.

**New Mechanism of Particle Acceleration and Relativistic Analogue of Fermi-Ulam Model**  
18620098a Moscow *TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA* in Russian  
Vol 77 No 1, Oct 88 (manuscript received 27 Mar 87)  
pp 154-160

[Article by L. D. Pustynnikov, All-Union Scientific Research Electric Power Institute]

[Abstract] The principal objective of this study is to explain how high-energy particles are generated in space. The Fermi-Ulam model was investigated within the framework of the special theory of relativity. It was found that in this case movements are possible which lead to an unlimited energy increase (theorems 3, 6) and the set of corresponding initial data is open in phase space. The article demonstrates theorem 2, which reveals a new acceleration mechanism existing in a more general situation. These results give a theoretical explanation of the experimental fact of the presence of particles with high energies because the movements of such particles must be regarded with allowance for the relativistic factor. It is postulated that such a model can be used in constructing real accelerators which will require a small space for their operation. The article consists of two sections. The first section examines the special case of a relativistic Fermi-Ulam model in which one of the walls is fixed; proofs are given. The second section formulates similar results for a general case. The ergodic theory, theory of partially hyperbolic dynamic systems and the Denjoy theorem are used in proofs of the theorems. Figures 2; references 7: 4 Russian, 3 Western.

**Theory of Radiation and Formation of Electron-Positron Pairs by Ultrahigh Energy Particles in Crystals With Incidence Angles Exceeding Lindhard Angle**  
18620080 Moscow *ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI* in Russian Vol 94 No 10, Oct 88 (manuscript received 3 Dec 87) pp 23-36

[Article by N. K. Zhevago, Atomic Energy Institute imeni I. V. Kurchatov]

[Abstract] The probability of bremsstrahlung and the probability of formation of electron-positron pairs by a

photon in a crystal may differ considerably from the corresponding probabilities in an amorphous medium. It is shown that the standard theory of coherent bremsstrahlung and pair formation can already be impaired with angles of incidence considerably exceeding the Lindhard angle for which the influence of the curvature of trajectories on the period of particle motion can be completely neglected. A theory is developed which makes possible an adequate description of electromagnetic processes in crystals in a relatively broad range of angles of incidence greater than the Lindhard angle. This more universal theory is free of those limitations which exist in the standard coherent bremsstrahlung theory and the theory based on the constant field approximation. This makes possible a more precise definition of the limits of applicability of the usually used approximations and explains some experimental results obtained at superhigh energies not fitting within the framework of existing concepts because the dipolar nature of the processes has not been taken into account. The results are compared with the corresponding results of existing theories and experimental data. Figure 1; references 18: 10 Russian, 8 Western.

**Series Expansion With Respect to Trajectory and Momentum Perturbations in Theory of Radiative Instabilities of Relativistic Electron Beams**  
18620051d Leningrad *PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI* in Russian  
Vol 14 No 15, 12 Aug 88 (manuscript received 17 Feb 88, in final version 1 Mar 88) pp 1404-1406

[Article by A. T. Bogdanov and M. V. Kuzelez, Moscow State University imeni M. V. Lomonosov]

[Abstract] Propagation of a relativistic rectilinear electron beam is analyzed for radiative instabilities arising upon excitation of charge-density waves in it, various mechanisms of their excitation and the corresponding instability modes being describable by a single system of three integro-differential equations analogous to those formulated earlier for a nonrelativistic electron beam and analyzed by expansion of their transcendental nonlinearities into power series with respect to electron trajectory perturbations. Now, in addition, their algebraic nonlinearities are expanded into power series with respect to electron momentum perturbations. This leads to a rather general theory of radiative instabilities in relativistic electron beams as well as in nonrelativistic ones, the same only constraint being that the magnitude of the instability increment in terms of frequency deviation by much smaller than the frequency of plasma oscillations in the electron beam. The system of equations thus transformed by the series expansions is solved for calculation of the maximum amplitudes of those perturbations and of the efficiency of radiation emission by electrons, adiabatic turn-on of the accelerating electric field constituting a special case. References 5: Russian.

**Self-Similar Solution to Equations of Dissipative Converging Shock Wave**

18620051e Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 15, 12 Aug 88 (manuscript received  
21 Apr 88) pp 1407-1410

[Article by A. B. Budko, Institute of Problems in Physics  
imeni S. I. Vavilov, USSR Academy of Sciences, Moscow]

[Abstract] A strong cylindrically symmetric shock wave converging to its axis while propagating through an ideal gas with a density profile  $g_{00}$  equal to  $g_{00}^{2x}$  is treated as a problem of dimensional analysis, with all dissipation losses except the bremsstrahlung loss disregarded and the gas assumed to be transparent for radiation. The corresponding system of three equations of gas dynamics, with two dimensional parameters which determine the gas or plasma flow, is reduced to one with a single variable and shown to have a self-similar solution of the first kind in a five-parameter space. The author thanks M.A. Liberman and A.L. Velikov for fruitful discussions, and L. P. Pitayevskiy for critique. References 4: Russian.

**Tunneling During Decay and Fusion of Complex Nuclei**

18620012a Moscow YADERNAYA FIZIKA in Russian  
Vol 48 No 1 (7), Jul 88 (manuscript received 13 Jul 87)  
pp 109-113

[Article by V. M. Shilov, Joint Institute of Nuclear Research, and A. V. Tarakanov, Saratov State University]

[Abstract] Tunneling of complex nuclei under the Coulomb barrier during decay and during fusion is considered on the basis of a multichannel model, rather than in the approximation of two one-dimensional channels, but including only channels with inelastic excitation of one of the colliding nuclei. Both nuclear reactions of  $^{222}\text{Ra}$  decay into  $^{14}\text{C}$  plus  $^{208}\text{Pb}$  and of  $^{14}\text{C}$  plus  $^{208}\text{Pb}$  fusion into  $^{222}\text{Ra}$  are evaluated, the corresponding equations of relative motion of nuclei in strongly coupled channels for the radial wave functions being solved analytically and then numerically. The results demonstrate a decay-fusion asymmetry of total barrier penetrability, coupling to inelastic-excitation channels causing the penetrability to increase only a little more for decay than for fusion. The authors thank F. A. Gareyev, B. N. Zakharyev, and Yu. M. Chuvilskiy for discussion. Figures 3; references 14: 7 Russian, 7 Western (1 in Russian Translation).

**Elastic Scattering of Negative Pions and Kaons by Protons With 43**

18620012b Moscow YADERNAYA FIZIKA in Russian  
Vol 48 No 1 (7), Jul 88 (manuscript received 22 Jul 87)  
pp 138-147

[Article by Yu. M. Antipov, V. A. Batarin, V. A. Bezubov, N. P. Budanov, Yu. P. Gorin, D. S. Denisov, O. V. Yeroshin, V. G. Kartasheva, I. V. Kotov, Yu. M. Melnik, A. I. Petrukhin, S. A. Polovnikov, and D. A. Stoyanova, Institute of High-Energy Physics, Serpukhov, A. V. Vishnevskiy, I. A. Gulutvin, Yu. A. Gornushkin, P. a. Kulinich, R. Leitner, G. V. Mitselmakher, A. Al. Nozdrin, A. G. Olshevskiy, S. Riemann, and J. Sedlak, Joint Institute of Nuclear Research, Dubna, R. V.

Pirtskhalava and V. N. Roynishvili, Institute of Physics, GSSR Academy of Sciences, Tbilisi, SIGMA-AYAKS Collaboration]

[Abstract] An experiment was performed by SIGMA-AYAKS collaboration, its purpose being to evaluate elastic scattering of negative pions and kaons by protons with an initial momentum of 43 GeV/s. The direction of particles in beams was determined with the aid of eight proportional-type chambers and two scintillation hodoscopes. The kind of particles was determined with the aid of one differential and two threshold Cherenkov counters. The target, liquid hydrogen, was placed inside a cylindrical self-quenched steamer chamber suitable for measuring the longitudinal y-coordinate of recoil protons. Scattering was measured with a magnetic spectrometer consisting of a magnetic with a  $75 \times 150 \times 560$  mm<sup>3</sup> ZXY-aperture and altogether 22 planes of chambers for measuring X-projections and Z-projections. Statistical data on negative pions and on negative kaons were gathered separately. These data have been processed with the aid of a computer for a numerical evaluation, in the exponential approximation, of the differential cross-sections for  $\pi^-$  and  $K^-$  scattering by protons over the 0.2-1.4 (GeV/s)<sup>2</sup> range of momentum transfer. The authors thank D. Yu. Bardin and B. Z. Kopeliovich for helpful discussion of theoretical problems. Figures 7; tables 5; references 17: 5 Russian, 12 Western.

**Inclusive Characteristics of Negative Pions Produced in pC and pTa Interactions With Proton Momentum of 10 GeV/s**

18620012c Moscow YADERNAYA FIZIKA in Russian  
Vol 48 No 1 (7), Jul 88 (manuscript received 24 Jun 87)  
pp 161-169

[Article by V. G. Grishin, I. A. Ivanovskaya, and Ye. N. Kladnitskaya, Joint Institute of Nuclear Research, Dubna. D. D. Armuliyski and N. O. Akhababyan, Institute of Nuclear Research and Nuclear Power Engineering, Sofia/Bulgaria/]

[Abstract] In the latest of experiments on inelastic interaction of protons and C, Ta nuclei such an interaction was triggered by bombardment of a target with protons having a momentum of 10 GeV/s, for the purpose of determining the inclusive characteristics of negative pions produced in the process in the 4. $\pi$  geometry. The experiment was performed in the High-Energy Laboratory at the Joint Institute of Nuclear Research, a 2 m long propane bubble chamber with two 1 mm thick tantalum plates in an external magnetic field of 1.5 T intensity being bombarded with 10 GeV/s protons from a synchrophasotron. Measurements were made on stereophotographs. The data have been analyzed for multiplicity, momentum, transverse, momentum squared, flight-angle, and longitudinal-velocity distributions of secondary negative pions, also their distributions with respect to the cumulative variable and with respect to the

Feynman variable, the contribution of secondary processes to production of negative pions having been found to be larger with a target nucleus of larger mass. Each distribution is describable as the sum of two exponential ones associated with carbon nuclei in  $C_3H_8$  and with Ta nuclei respectively, all being asymmetric relative to zero and those corresponding to pTa interaction than those corresponding to pC interaction. The data are compared with data on analogous interaction involving 45.2 GeV/2 protons in an earlier experiment and with theoretical predictions on the basis of Dubna's variant of the cascade model. The authors thank V. D. Toneyev for fruitful discussions. Figures 8; tables 6; references 14: 12 Russian, 2 Bulgarian.

**Production of W. Bosons in Strong Electromagnetic Field and Their Contribution to Radiative Shift of Electron Mass**

18620012d Moscow YADERNAYA FIZIKA in Russian Vol 48 No 1 (7), Jul 88 (manuscript received 22 Jun 87) pp 179-188

[Article by V. Ch. Zhukovskiy and A. V. Kurilin, Moscow State University]

[Abstract] Decay of an electron into a W-boson and an electron neutrino in a strong electromagnetic field is analyzed for the effect of such a field on W-boson production and for their contribution to the radiative shift of electron mass. Calculations are based on the Glashow-Weinberg-Salam model and include electroweak correction to that shift by analytic continuation of the field intensity parameter. Solitary photoproduction of W-Bosons by interaction of gamma-quanta and relativistic electrons in an electromagnetic field is then evaluated in the second order of the perturbation theory for the interaction constant  $g$ , considering the probability of an electron decaying into a W-boson and a neutrino in the crossed field and wave configuration, with use of two diagrams describing respectively virtual production of an electron in the s-channel with its subsequent decay and then its exchange for a W-quantum in the t-channel. References 42: 22 Russian, 20 Western.

**Nonrelativistic String**

18620012e Moscow YADERNAYA FIZIKA in Russian Vol 48 No 1 (7), Jul 88 (manuscript received 2 Jul 87) pp 296-298

[Article by M. O. Katanayev, Institute of Problems in Engineering Physics]

[Abstract] A new Lagrangian describing the dynamics of a nonrelativistic string is constructed, this Lagrangian being invariant with respect to generalized transformations of coordinates on the world surface of a string as well as with respect to Galilean transformations. It essentially represents the nonrelativistic limit for the Lagrangian of an ordinary boson string and, in the linear approximation, describes transverse vibrations of such a

string of rotation of a straight one at a constant angular velocity. As the small parameter which will conserve that reparametrizability invariance has been selected the ratio of areas of world surface projects onto the coordinate planes, this ratio in the time gauge reducing to the ratio  $v^2/c^2$  of velocity squared to speed of light squared. The boundary conditions for an open string derive from the principle of least action, there being no problem of velocities higher than the speed of light at both ends of a closed one. The author thanks I. V. Volovich for discussion. References 67: 3 Russian, 3 Western.

UDC 539.1.01

**Nonlinear Two-Proton Interactions in Strong Magnetic Field**

18620013a Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKIA in Russian Vol 31 No 6, Jun 88 (manuscript received 18 Nov 85) pp 16-19

[Article by V. V. Skobelev and N. O. Khasayev]

[Abstract] Two nonlinear photon-photon interactions in a superstrong magnetic field, scattering by a nucleus and fusion on a nucleus, are analyzed in the "two-dimensional approximation" of quantum electrodynamics. Calculations based on the relation between matrix elements of corresponding loop diagrams in the low-energy approximation with respect to electron mass yield cross-sections for these processes which are respectively  $0.012(B/B_0)^2$  and  $0.28(B/B_0)^2$  times larger than in the absence of a magnetic field ( $B$  - induction of magnetic field,  $B_0$  equal to  $m^2/e$ ,  $m$  - electron mass,  $e$  - electron charge). These estimates are purely theoretical inasmuch as magnetic fields much stronger than  $B_0$  have not yet been produced in laboratory practice. Figures 1; references 17: 6 Russian, 11 Western.

**Structure of Topological Solitons in Skyrme's Model**

18620005b Moscow TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA in Russian Vol 75 No 3, Jun 88 (manuscript received 27 Mar 87) pp 353-360

[Article by I. R. Kozhevnikov, Yu. P. Rybakov, and M. B. Fomin, 'Amity of Nations' University imeni Patrice Lumumba]

[Abstract] The structure of other than Skyrme's ansatz soliton-like solutions to field equations in four dimensional  $SU(2)$ -chiral models is analyzed, Skyrme's  $SU(2)$ -chiral model of simplest nonlinearity in nuclear physics treating a baryon as a soliton endowed with a topological charge  $Q$  and a nucleon ( $Q$  equal to 1) as a spherically symmetric configuration also known as Skyrme's "hedgehog" ansatz. Following a description of Skyrme's model, in which the field manifold is an  $SU(2)$ -homeomorphic three-dimensional sphere, it is demonstrated that in this model there exist more energy-favorable field configurations for higher homotopic classes with  $Q$  larger than 1 and an axisymmetric one corresponds to the absolute energy minimum for  $Q$  equal to or larger than 2. Figures 2; references 14: 7 Russian, 7 Western (1 in Russian translation).



**Anomalous Light Absorption by Microparticle**

18620091c PISMA V ZHURNAL

EKSPERIMENTALNOY I TEORETICHESKOY

FIZIKI in Russian Vol 49 No 1, 10 Jan 89 (manuscript received 18 Nov 88) pp 3-5

[Article by G. N. Nikolayev, Automation and Electrometry Institute, Siberian Department, USSR Academy of Sciences]

[Abstract] The cross section of light absorption by an isolated spherical microparticle whose radius is much less than the wavelength of the irradiating light is well defined, but the cross section of resonant interaction between an atom and light is substantially greater. Accordingly, an effort was made to clarify the possibility of cascade transfer of energy from light to an atom and from it to a microparticle. The energy transfer from an atom excited by light to a microparticle occurs due to absorption of the electrical field of an atomic dipole induced by light. An induced dipole arises under the influence of three fields: initial field of light wave, field of the microparticle dipole induced by this wave and the polarization field of a microparticle generated by an atomic dipole. The magnitude of the induced atomic dipole is dependent on the irradiation mode in the considered system. Two modes are examined: stationary and pulsed. An unexpected result was obtained; a decrease in the role of cascade energy transfer with approach of an atom to a microparticle. This is attributable to a broadening of the transition line with approach of the atom to a particle, which makes difficult the induction of a dipole moment of an atom by radiation. However, the most important finding is that the efficiency of cascade energy transfer from radiation through a resonant atom to a microparticle is essentially dependent on the irradiation mode. In the case of pulsed radiation energy transfer to a microparticle may be more effective by a factor of  $10^3$  than the direct absorption of light by a microparticle. References 4: 3 Russian, 1 Western.

UDC 535.375.5

**Determination of Parameters of Heterophase Aqueous Media by Laser Spectroscopy of Raman Light Scattering**

18620077d Moscow DOKLADY AKADEMII NAUK

SSSR in Russian Vol 303 No 2, Nov 88 (manuscript received 14 Jul 87) pp 345-349

[Article by S. M. Glushkov, I. M. Panchishin and V. V. Fadeyev, Moscow State University imeni M. V. Lomonosov]

[Abstract] On the basis of a number of properties of the Raman scattering spectra of water it is possible to measure the partial concentrations of water molecules in the liquid and solid phases and to solve problems with three or more parameters, such as measuring the concentration of dissolved salts and medium temperature in

addition to the mentioned parameters. The experiments were carried out with a laser Raman scattering spectrometer using a  $180^\circ$  scheme for registry of the scattered signal. This scheme is free of polarization effects affecting the form of the spectra. The use of parallel (in 500 channels) registry of the signal spectrum using an optical multichannel analyzer made it possible to obtain spectra with the required resolution. The method for determining the partial concentrations of water molecules belonging to the liquid and solid phases (free of impurities) is described in detail. The method is suitable for determining the partial quantities of water and ice in their mixture for objects in which the characteristic extent of the homophase regions is much less than the extent of the excitation zone. When investigating objects in which homophase regions have an extent comparable to the extent of the excitation volume, such as crystallization on a continuous front, additional errors may appear due to attenuation of the sounding radiation during propagation in the phase region closest to the source and reflection at interfaces. The case of water containing impurities is also examined. Figures 4; references 8: 4 Russian, 4 Western.

UDC 519.23:535.33

**Dialogue Approach to Solution of Inverse Problems in Processing and Interpretation of Spectroscopic Data**

18620093c Minsk ZHURNAL PRIKLADNOY

SPEKTROSKOPII in Russian Vol 49 No 4, Oct 88 (manuscript received 4 Sep 87) pp 642-647

[Article by D. V. Yudin and V. V. Gorchakov]

[Abstract] A new dialogue approach is proposed for solution of inverse problems in the processing and interpretation of spectra, making it possible to include in the processing and interpretation a priori information on the investigated spectrum of a hypothetical, model character, which until now has been neglected. It is proposed that the a priori data be formalized as a statistical model of a directly unobservable spectrum which initially cannot be identified with information. The mathematical tools used in such dialogue include not only generally accepted methods, but also solution of interpretation problems and criteria which on the basis of measurements make it possible to check the a priori data used, to make decisions on whether these data constitute information or disinformation. The reliability of the final results can be checked. The article gives examples of solution of a number of special problems in the interpretation of spectra illustrating the possibilities of the dialogue approach. Figures 4; references 6: 5 Russian, 1 Western.

UDC 535.34

**Absolute Intensities of Bands in IR Spectra of Cu-Porphyrins**

18620093d Minsk ZHURNAL PRIKLADNOY

SPEKTROSKOPII in Russian Vol 49 No 4, Oct 88 (manuscript received 8 Jun 87) pp 667-670

[Article by L. L. Gladkov and G. D. Yegorova]

[Abstract] IR spectroscopy is widely used in research on porphyrins. Until now the frequency characteristics of

the spectra have been used and quantitative data on band intensities are lacking because they are quite sensitive to change in intra- and intermolecular interactions. A method is proposed for filling this gap. It was possible to determine the absolute intensities of bands in the IR spectra of metalloporphyrins: Cu-porphin, Cu-tetraphenylporphin and Cu-octaethylporphin. The availability of interpretations of IR spectra for these compounds and the high degree of symmetry for these complex molecules dictated their choice as research objects. It is shown that the addition of phenyl or alkyl groups to the porphyrin macrocycle results in considerable changes in electrooptical parameters relative to the substituent bonds closest to the macrocycle. Figures 2; references 8: 6 Russian, 2 Western.

**Superradiation and Superluminescence in Optical Cavity and Self-Excitation in It**

18620040d Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 9, Sep 88 (manuscript  
received 11 Mar 88) pp 40-48

[Article by A. V. Andreyev, O. Yu. Tokhomirov, and M. V. Fedotov, Moscow State University imeni M. V. Lomonosov]

[Abstract] Superradiation and superluminescence in the cavity of a pulsed solid-state laser are considered, taking into account strong reflection at boundaries of the active volume. Of the two characteristic parameters in the equations of laser dynamics derived from short Maxwell-Bloch equations, both parameters determining the dynamics of polyatomic decay inside the cavity, one depends on the active medium only and one depends also on the pump. A theory of cooperative polyatomic decay is constructed which reveals a different dependence of superradiation and of superluminescence on the cavity Q-factor. The conditions for self-excitation are analyzed and its threshold is determined on this basis, in a manner convenient for experimental verification. A criterion for superradiation is established according to which the power of a superradiation pulse can be increased and its duration shortened, the maximum attainable intensity depending on the reflectance of the cavity mirrors. Figures 7; references 7: 3 Russian, 4 Western.

UDC 530.145+530.5

**Quantum Limitations of Response of Gravity Wave Detectors With Free Masses**

18620090a Tomsk IZVESTIYA VYSSHIKH  
UCHEBNYKH ZAVEDENIY: FIZIKA in Russian  
Vol 31 No 9, Sep 88 (manuscript received 15 Jan 86)  
pp 14-19

[Article by S. A. Tsypliyayev, Tomsk Pedagogic Institute imeni Leninskiy Komsomol]

[Abstract] The problem of registry of the classical effect when tracking the coordinate of a free particle is examined within the framework of nonrelativistic quantum

mechanics. It is shown that there is no fundamental response limitation ("standard quantum limit"). An arbitrarily small perturbation can be registered due to the preparation of a system in a quantum state having a negative quantum coefficient of the observed coordinate and impulse. It is shown that it applies to generalized coherent states (compressed states). Arguments are given in support of absence of fundamental quantum limits of the magnitude of the registered classical effect when measuring an arbitrary observed process with a continuous spectrum. Thus, the presented materials show that the "standard quantum limit response" can be exceeded. This is examined in detail because earlier the existence of this limit was regarded as a demonstrated theorem. This research reveals the merits of states associated with their correlation properties, which can find application not only in the problem of detecting gravity waves, but also in other precise experiments. References 13: 4 Russian, 9 Western.

**Scattering of X-rays by Weakly Rough Surfaces**

18620030d Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 8, Aug 88 (manuscript  
received 7 Jul 87) pp 203-216

[Article by A. V. Vinogradov, N. N. Zorev, I. V. Kozhevnikov, S. I. Sagitov, and A. G. Turyanskiy, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences]

[Abstract] Scattering of x-rays by weakly rough surfaces is analyzed, the scattering indicatrix being calculated on the basis of the Andronov-Leontovich perturbation model and the integral intensity of scattered radiation being used for calculating the asperity height. The surface of a dielectric material is assumed to bound on vacuum, whereupon it is also assumed to be an isotropic one. On the premise that only small glancing angles, corresponding to a large reflection coefficient, need to be considered, general calculation of the indicatrix is followed by its calculation for glancing angles smaller than and for glancing angles larger than the critical angle for total internal reflection. The second case is characterized by anomalous scattering, the Yoneda effect, namely by two peaks which tend to merge as the glancing angle approaches the critical one. This effect was verified experimentally on surfaces of KS glass and acrylic glass  $C_3H_4O_2$ , also on a 400 nm thick Sn film on a KS substrate, with x-rays from a BSV-8 tube glancing at angles of 0.5-1.0 deg and the 0.154 nm  $CuK_{\alpha}$  radiation line extracted by a monochromator made of pyrolytic graphite. The authors thank L. A. Vaynshteyn, V. I. Mikerov, V. A. Slemzin, L. A. Smirnov, V. I. Tatarskiy, I. L. Fabelinskiy, and I. G. Yakushkin for discussion. Figures 6; references 30: 17 Russian, 13 Western.

UDC 535.35

**Additive Compounding of Electronic Excitations of Yb on Ho-Ions**

18620039b Minsk ZHURNAL PRIKLADNOY  
SPEKTROSKOPII in Russian Vol 49 No 2, Aug 88  
(manuscript received 12 Jun 87) pp 255-260

[Article by T. M. Kozhan, V. V. Kuznetsova, I. I. Sergeyev, and V. S. Khomenko]

[Abstract] Additive compounding of electronic excitations of Yb on Ho-ions in  $YCl_3$  is evaluated, considering that anti-Stokes glow of Ho builds up within both green and red ranges of the spectrum as the high-excitation states  $^3S_2$  and  $^3F_3$  become populated along any of the various possible paths. Theoretical analysis of the attendant energy transfers occurring at various rates is supported by experimental data on the temperature dependence, over the 77-400 K range, of the relative intensities of green glow at the 540 nm wavelength and red glow at the 650 nm wavelength, green glow becoming stronger and red glow becoming weaker with dropping of the temperature. Figures 3; references 6: 3 Russian, 3 Western.

UDC 535.345

#### New Type of Cutoff Filter for Far-Infrared Range of Spectrum

18620039d Minsk *ZHURNAL PRIKLADNOY SPEKTROSKOPII* in Russian Vol 49 No 2, Aug 88 (manuscript received 11 Nov 85, after completion 1 Sep 87) pp 317-320

[Article by V. G. Vereshchagin and V. V. Morozov]

[Abstract] A new type of filter cutting of near-infrared radiation and thus facilitating far-infrared spectroscopy has been developed, namely a modification of conventional scattering-interference filters. It consists of two elementary stacks, only 7-8 layers of a polydisperse material with different average grain sizes in each but all having a high refractive index, which ensures a sharp contrast and thus a steep cutoff even with a wide dispersion of grain sizes in the layers of each stack. The material of such a filter transmits long-wave radiation without hardly absorbing any and its grains do not scatter much of it. Such filters produced from polyethylene powder were tested, with satisfactory results, in an FIS-3 Hitachi two-beam spectrophotometer for passing principal long-wave radiation as well as with two one-beam spectrometers for stopping parasitic background radiation. Such a filter with up to 80 pct transmittance can be designed for a 0.7-0.8 cutoff slope at any radiation edge above the 0.035 mm wavelength. Figures 2; references 8: 4 Russian, 4 Western.

UDC 539.213

#### Inelastic Scattering of Light by Fractal Vibration Modes in Polymers

18620046a Leningrad *FIZIKA TVERDOGO TELA* in Russian Vol 30 No 8, Aug 88 (manuscript received 26 Feb 88) pp 2360-2366

[Article by V. A. Bagryanskiy, V. K. Malinovskiy, V. N. Novikov, L. M. Pushchayeva, and A. P. Sokolov, Institute of Automation and Electrometry, Siberian Department, USSR Academy of Sciences, Novosibirsk]

[Abstract] Spectral and fractal dimensionalities in amorphous high-molecular polymer glasses are established on the basis of experimental data and theoretical analysis

pertaining to inelastic scattering of light in such disordered media. Calculations are made according to Shuker-Gamon and Martin-Brenig theories. Measurements were made by the method of low-frequency Raman scattering in a 90 deg configuration, with a DFS-24 dual monochromator whose slit had a spectral width of  $1.5 \text{ cm}^{-1}$ . Scattering of 676 nm light in polymethyl methacrylate, oligomethyl methacrylate, and polystyrene was measured at temperatures covering the 100-300 K range, with the field vector of the incident exciting wave either normal or parallel to the plane of scattering and the field vector of the scattered wave always normal to that plane. Their Raman spectra, representing the frequency dependence of the scattering intensity, have been normalized with inclusion of the spectral characteristic of the instrument as well as the frequency factor and the temperature factor. These spectra indicate, by a change of slope, the critical frequency at which transition from fracton vibration mode to phonon vibration mode and correspondingly from fractal to spectral dimensionality occurs. Figures 3; references 40: 5 Russian, 35 Western.

#### Study of Collisional Mixing of $B^3\Pi$ and $A^3\Sigma$ States in Nitrogen Molecule by Method of Laser Fluorescence

18620061a Leningrad *OPTIKA I SPEKTROSKOPIYA* in Russian Vol 65 No 1, Jul 88 (manuscript received 23 Apr 87) pp 43-48

[Article by Yu.Z. Ionikh, N.P. Penkin, N.V. Chernysheva, and O.G. Yartseva]

[Abstract] An experimental study of collisional transitions between  $B^3\Pi$  and  $A^3\Sigma$  states in a  $N_2$ -molecule was made by the method of laser fluorescence, glow discharges of at least 1 ms duration being produced in tube 3 mm in diameter containing a 99.999 pct pure He plus 3 pct  $N_2$  mixture under a pressure of 1 torr. The discharge current was held at the 10 mA level for the basic part of the experiment and varied over the 5-50 mA range for additional data. The positive column was monitored during glow discharge and afterglow of the  $B^3\Pi$  state in bands of the first positive series as well as afterglow of the metastable  $A^3\Sigma$  was monitored during 1-4 ms long pauses between discharges. The laser used for this experiment was an optically pumped pulsed LZhl-43 dye laser with rhodamine 6G, unsubstituted rhodamine, or their mixture as active medium, emitting pulses of up to 0.4 J energy and of 0.005 ms duration in a beam 2.5 cm in diameter. The emission band was 3.5 nm wide or, with a selector in the cavity, narrowed down to 0.7 nm. The laser was aligned coaxially with the discharge tube, fluorescence was picked up laterally with the FEU-62 photomultiplier feeding signals to an S8-13 memory oscillograph oriented at right angles to the tube. Decay of the  $B^3\Pi$  state during afterglow was recorded in two ways, by the method of delayed coincidences in the photon count mode with an AI-256 pulse analyzer (time resolution 0.002 ms) and in the analog mode with an F-36 digital storage. The data confirm the collisional



excitation transfer mechanism of mixing of A(7) and B(0) states including also mixing of W(0) and B(0) states so that the respective rate constants can be quantitatively estimated. The authors thank V.I. Blashkov for consultations on the measurement technique. Figures 4; references 12: 2 Russian, 10 Western.

#### Characteristics of Stimulated Scattering in Low-Viscosity Fluids

18620061b Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 65 No 1, Jul 88 (manuscript received 2 Feb 87, in final version 1 Mar 88) pp 56-61

[Article by N. P. Malomuzh and S. B. Pelishenko]

[Abstract] Considering that not only heat scattering but also stimulated light scattering is an important source of information about collective modes of molecular movements and considering that stimulated scattering in low-viscosity media will most likely reveal the fine structure of the tail of the Rayleigh line, stimulated Raman scattering by anisotropy fluctuations in such media is analyzed theoretically for its effect on anisotropy relaxation. Calculations for polarized stimulated Raman scattering in media with a kinematic viscosity so low that  $\nu\eta^2\tau$  does not exceed unity ( $\nu$ - kinematic viscosity,  $q$ - change in wave vector upon scattering,  $\tau$ -anisotropy relaxation time) based on the model with only one internal relaxing parameter yield the scattering amplification and then an anisotropy relaxation time slightly shorter than according to experimental data on heat scattering. The difference is attributed to longitudinal modes, though their distorting effect is shown to be appreciable only in media with a very low viscosity. The authors thank V.S. Starunov for interest and discussion. Figures 2; references 13: 12 Russian, 1 Western.

#### Theory of Two-Stage Trough Formation in Spectrum by Light Pulses

18620061c Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 65 No 1, Jul 88 (manuscript received 26 Nov 86, in final version 5 Feb 88) pp 49-55

[Article by I.K. Rebane]

[Abstract] Formation of narrow troughs in spectra of materials containing impurities by selective pulsed photoexcitation of pure electron transitions of impurity centers within the nonhomogeneous band is analyzed as a two-stage process, a theory of such a trough formation by steady photoexcitation of electron transitions for attainment of a better spectral resolution as well as for furtherance of high-density data recording and processing already having been developed. The kinetics of trough formation is treated mathematically as a transformation of the nonuniform distribution of centers with respect to the frequency of a given transition and is analyzed accordingly for a three-level system, a two-dimensional distribution function being necessarily introduced so as to account for the nonuniform distribution of both 0-to-1 and 1-to-2 transition frequencies.

Following an analysis of steady trough photoformation, for reference and comparison, action of a short second pulse is considered and a dependence of the trough width on the pulse delay is established. Quantitative estimates are made pertaining to formation of troughs in 0-to-1 absorption spectra and in two-stage 0-to-1 then 1-to-2 pulse excitation spectra, the trough width monotonically decreasing with increasing delay of the second pulse. Modulational widening of excited levels 1 and 2 by phase relaxation, significant except at very low temperatures about 1 K and that of level 1 especially in the case of a short second pulse, is subsequently taken into account and found to add to the prior trough width without being compensated. Figures 1; references 17: 9 Russian, 8 Western.

#### Formation of Prescribed Wavefront in Conjugate-Ring Laser Cavity

18620061d Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 65 No 1, Jul 88 (manuscript received 11 Jun 87) pp 167-170

[Article by V.V. Lyubimov and L.V. Nosova]

[Abstract] The feasibility of wavefront reversal in a conjugate-ring laser cavity is examined, this being achievable by recording positive images with the original laser beam on transparencies and placing the latter in Fourier planes of the cavity. First is considered reconstruction of the wavefront curvature, first with one transparency and then with two or more additional ones, necessary calculations having been made by the method of successive approximations with the aid of the fast Fourier transformation for a smooth wavefront with a constant amplitude of amplitude distortions in a cavity formed by one-dimensional mirrors. Next is considered reconstruction of a wave with an intricate profile. Formation of a prescribed wavefront at a wavelength other than that of the original radiation is shown to be possible with the aid of a selector a laser beam carrying smooth aberrations, because the peaks of its amplitude distribution coincide with caustic surfaces and the form of the latter in achromatized optics does not depend on the wavelength. Figures 4; references 8: 6 Russian, 2 Western.

#### Synthesis of Images of Objects Viewed Through Randomly Nonhomogeneous Medium With Aid of Active Michelson Interferometer

18620061e Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 65 No 1, Jul 88 (manuscript received 23 Apr 87, in final version 1 Feb 88) pp 202-204

[Article by A.V. Anufriyev, A.L. Volpov, Yu.A. Zimin, and V.N. Lopatkin]

[Abstract] A method of synthesizing images of objects viewed through a randomly nonhomogeneous medium such as a turbulent atmosphere with the aid of an active Michelson interferometer is proposed which requires only three measurements at three wavelengths within a

narrow band during the "freezing in" period, many measurements at only one wavelength and consequently high-speed data processing during this period being required while synthesis by the method of signal averaging over distortions by the medium requires many statistically independent measurements and thus a much longer observation period. An analysis of the configuration, of principal concern being the phase components of reflected light, indicates that this method can be implemented with an adjustable interferometer base and three sources of coherent light: one operating at a fixed frequency and the frequencies of the other two adjustable. The coherence length for each source must be larger than the difference of optical paths due to nonhomogeneity of the medium and due to mismatch of the interferometer arms. References 4; Russian.

**Speckle Correlator for Measuring in Real Time Displacements of Rough Surface**

18620061f Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 65 No 1, Jul 88 (manuscript received 15 Jun 87, in final version 2 Feb 88) pp 212-214

[Article by V.M. Dobrido, V.V. Manikalo, and Yu.P. Presnyakov]

[Abstract] Measuring displacements of a rough surface with the aid of the speckle effect is considered, this method being based on correlation of the intensity of diffusely coherent light and the recorded negative image of the surface. It is demonstrated by analysis of the optical system and its geometry that use of a speckle correlator makes it possible to measure not only the tangential components of the displacement vector but also in real time purely normal displacements of a rough surface. The apparatus for such measurements include a He-Ne laser, a lens regulating the size of the illuminated surface segment, a lens positioned with its focus near the center of that surface segment and with its optical axis at a given angle to the normal to the object surface, a speckle transparency, and a photomultiplier. In a practical experiment such a speckle correlator was used for analyzing vibrations of a membrane excited by a sound source and recorded on an oscillograph. Figures 2; references 3: 1 Russian, 2 Western (1 in Russian translation).

**Polarization of Laser-Excited Fluorescence**

18620061g Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 65 No 1, Jul 88 (manuscript received 31 Dec 87) pp 237-240

[Article by V. P. Klochkov and A. G. Makogonenko]

[Abstract] The phenomenon of noncoherent superluminescence following excitation of an electronic state by coherent light is analyzed, the population of the excited state being almost independent of the excitation power but the intensity of fluorescence increasing as the excitation power is increased. The phenomenon is attributed to spontaneous radiation emission and dependence of its rate constant on the excitation power, an increase of that rate also

changing the excitation power dependence of the degree of fluorescence polarization. Calculations made for rhodamine 6G and unsubstituted rhodamine with nonuniform broadening of spectral line taken into account, on the basis of theoretical relations fitting experimental data, confirm that dependence of the rate constant of radiative transitions on the excitation power is most likely responsible for the increase of the fluorescence intensity upon population saturation of the excited state and for the attendant high degree of fluorescence polarization. Figures 2; references 7: 5 Russian, 2 Western.

**Planar Waveguides With Singular Dispersion Law**

18620045h Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 14 No 13, 12 Jul 88 (manuscript received 1 Mar 88) pp 1161-1164

[Article by K. A. Landa, M. A. Igolinskaya, and T. I. Yanina, Kuzbass Polytechnic Institute, Kemerovo]

[Abstract] An experimental study of planar optical glasses with waveguide properties was made, its purpose being to determine the dispersion laws for their refraction characteristics analogous to those of cast bulk glasses on plane ion-exchange surface of which a singular dispersion law for the refractive index and the birefringence had already been detected. Planar waveguides in the form of 2 mm thick and 20-30 mm<sup>2</sup> large plane-parallel plates made of various optical glasses, crown glasses and flint glasses containing 5-25 mol.pct NaO, were produced by the low-temperature ion-exchange diffusion process from melts of K, Rb, Ag, Ta salts at temperatures below the glass transition point so as to ensure a graded-index structure. They were probed with laser beams at 436 nm, 546 nm, 589 nm, 632 nm wavelengths, waveguide modes being excited within 0.001-0.020 mm thick ion-exchange surface layers, for determination of the number of modes  $m$  and measurement of the refractive index  $n_m$  for each mode at each wavelength as well as of the mode anisotropy characterized by the difference  $n_{TM,m} - n_{TE,m}$  between refractive indexes for each mode with TM-polarization and with TE-polarization respectively. Figures 2; references 9: 7 Russian, 2 Western.

**Effect of Light Pressure on Processes in Plasma Produced by Laser Treatment**

18620045c Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 14 No 13, 12 Jul 88 (manuscript received 23 Nov 87, in final version 14 Apr 88) pp 1183-1187

[Article by G. A. Sheroziya]

[Abstract] Generation of an electric plasma surface current under light pressure on a plasma of a conducting target material produced by treatment of the latter with laser radiation was confirmed in a direct experiment

involving measurement of this current and evaluation of the attendant drag effects. The experiment was performed with a Nd-laser emitting nonpolarized radiation in pulses of 10 J energy and 40 ns duration, such a pulse being focused on 20x50 mm<sup>2</sup> large plates of various target metals facing the laser beam at various angles. A voltage pulse of 20-30 ns duration was recorded at the copper plate-plasma interface, its amplitude depending sinusoidally on the angle of laser beam incidence and increasing linearly with sharper focusing as well as parabolically with higher laser pulse energy. The current flowing on the plasma side was shunted by a current flowing on the metal side, the magnitude of the shunting effect having been evaluated both theoretically and in a control experiment with a target consisting of a 3 mm thick teflon filler between two 10 mm thick metal sheaths. The results of the experiment indicate that the drag current flowing at the surface of a plasma layer causes a red Doppler shift in the reflection-and-scattering spectrum, electrons which scatter laser radiation upon stimulated bremsabsorption of photons evidently acting as "moving away" mirrors. The author thanks G. A. Askaryan for interest and helpful comments, S. V. Gorbunov and I. V. Postovskiy for assistance in performing the experiment, and colleagues at the Institutes of Physics (USSR Academy of Sciences) for participating in discussion and interpretation of the results. Figures 2; references 10: Russian.

**Parametric X-Ray Emission in Crystals Upon Passage of Ultrasonic Wave**

18620009b Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 7, Jul 88 (manuscript  
received 1 Dec 87) pp 109-117

[Article by V. G. Baryshevskiy and I. V. Polikarpov,  
Scientific Research Institute of Nuclear Problems,  
Belorussian University imeni V. I. Lenin]

[Abstract] A theory of parametric x-ray emission in crystals upon passage of an ultrasonic wave is constructed, dependence of the effective refractive index on both frequency and amplitude of the acoustic field being shown to influence the radiation spectrum and pattern. Both are calculated first for a fast charged particle moving through a crystal in an alternating external field,

considering that an electromagnetic wave originating inside a crystal becomes spherical far outside it. The radiation pattern is then calculated for a weakly absorbing thin crystal, the thickness of such a crystal being smaller than the absorption length but larger than the extinction length, and for a strongly absorbing thick crystal. The results reveal that an ultrasonic wave appreciably alters the refraction characteristics of crystal as well as the coherence length under conditions of dynamic diffraction and acoustoparametric resonance, dependent on its wave vector, as a consequence increasing both spectral and angular densities of parametric x-radiation while also causing x-ray extinction beats. References 21: Russian.

**Ignition of Fuel Mixture by Flame Front Propagating Behind Shock Wave**

18620007a Novosibirsk FIZIKA GORENIYA I  
VZRYVA in Russian Vol 24 No 3, May-Jun 88  
(manuscript received 8 Jul 86, after completion  
30 Sep 86) pp 42-44

[Article by N. I. Mayorov and I. K. Fedoseyeva, Moscow]

[Abstract] A tubular 175 mm long precombustion chamber 8 mm in diameter, closed at one end and connecting to a 470 mm long combustion chamber with 36x36 mm<sup>2</sup> square cross-section, was built with a diaphragm at the open end for experimenting with ignition of fuel mixtures by a flame front propagating behind a shock wave generated by a spark plug inside near the closed end while varying the size of the orifice at the open end over the 1.5-8 mm range by means of that diaphragm. As fuel mixtures were tested stoichiometric 2H<sub>2</sub> plus O<sub>2</sub> and CH<sub>4</sub> plus 2O<sub>2</sub> mixtures in the precombustion chamber with initial pressure of 0.04-0.1 MPa, air plus 7 percent CH<sub>4</sub> in the main combustion chamber under constant pressure of 0.1 MPa. Ignition did not occur with a 1.5 mm large orifice at the open end, an at least 4 mm large one being required for reliable ignition. Propagation of shock wave, flame front, and combustion front was monitored with the aid of heat markers and their displacement indicating the distribution of gas velocity between shock wave and flame front. The results of this experiment confirm the feasibility of reliably intensifying the combustion of low-grade fuel in the main chamber by means of a flame ignited in and coming from a precombustion chamber. Figures 5; references 2: Russian.



UDC 533.9:621.039.62

**Influence of Radial Diffusion on Thermonuclear Yield in Tokamak**

18620116a Moscow FIZIKA PLAZMY in Russian  
Vol 15 No 1, Jan 89 (manuscript received 23 Mar 87,  
after revision 3 Nov 87, after second revision 29 Mar 88)  
pp 3-11

[Article by F. S. Zaytsev, A. P. Smirnov and P. N. Yushmanov, Moscow State University imeni M. V. Lomonosov; Atomic Energy Institute imeni I. V. Kurchatov]

[Abstract] A study was made of the distribution functions of deuterium and tritium in a tokamak in the presence of radial diffusion caused by the finite thickness of trajectories of particles and undulating radial diffusion. The distortion of a Maxwellian distribution due to diffusional transport processes in the plasma of a tokamak with thermonuclear parameters is examined. Both neoclassic transfer, caused by the finite thickness of banana orbits, and the diffusion of particles arising as a result of toroidal nonuniformity of the magnetic field, are taken into account. Distortions of the distribution functions of deuterium and tritium are computed numerically on the basis of a two-dimensional kinetic equation. The results of the computations are compared with analytical estimates. The distorted distributions are used in determining the thermonuclear yield in the plasma of the tokamak reactor. The research revealed that neoclassic radial transfer of fast ions exerts no influence on the power of a tokamak reactor with parameters of the INTOR apparatus type. D, T reaction energy losses arise as a result of the presence of magnetic field undulation. When the electron temperature is greater than the ion temperature the fraction of losses is somewhat reduced. Computations for different plasma temperature profiles show that in this case there is a change in the energy contribution of the D, T reaction and its radial redistribution. Figures 5; references 11: 6 Russian, 5 Western.

UDC 533.922

**Potential Scattering of Slow Electrons in Laser Radiation Field**

18620116b Moscow FIZIKA PLAZMY in Russian  
Vol 15 No 1, Jan 89 (manuscript received 24 Dec 87,  
after revision 18 Feb 88) pp 69-76

[Article by V. N. Pomerantsev, A. M. Popov, O. B. Popovichcheva and T. V. Rakhimova, Nuclear Physics Scientific Research Institute, Moscow State University imeni M. V. Lomonosov]

[Abstract] Research on interaction between powerful laser radiation and matter dictates a study of the induced braking effect (solution of the problem of potential scattering in the presence of an electromagnetic wave). This is pertinent in research on interaction between laser

radiation and low-temperature plasma. A study was therefore made of the potential scattering of slow electrons in a weak external electromagnetic field. An expression is derived for relating the amplitude of the n-photon induced braking effect and elastic scattering for electrons outside the framework of the Born approximation. Numerical computations of the section of the multiphoton induced braking effect were made with electron scattering on model potentials. The results of computation of the sections of the single-photon braking effect were compared with computations made using known formulas. It is shown that solution of the problem of electron scattering in the field of laser radiation in a specific gas requires precise theoretical computations or experimental determination of the induced braking effect section. Figures 4; references 16: 9 Russian, 7 Western.

UDC 534.222.2:553.81:54-114

**Synthesis of Diamond by Dynamic Loading of Organic Matter**

18620076c Moscow DOKLADY AKADEMII NAUK  
SSSR in Russian Vol 303 No 3, Nov 88 (manuscript  
received 20 Jul 88) pp 625-627

[Article by V. F. Anisichkin, I. Yu. Malkov and V. M. Titov, corresponding member, USSR Academy of Sciences, Hydrodynamics Institute imeni M. A. Lavrentyev, Siberian Department, USSR Academy of Sciences, Novosibirsk]

[Abstract] The synthesis of diamond under the dynamic loading of organic matter, a logical development of the method of synthesis from organic explosives, is described. In order to create the necessary conditions for the synthesis of diamond the organic substances were introduced as additives into charges of bulk explosives. After expansion of the detonation products their condensed phase was subjected to chemical and x-ray structural analyses. In some experiments, in order to increase pressure and temperature, the mixtures of investigated substances and explosives were enveloped by the detonation of a more powerful explosive. These experimental schemes made it possible to maintain pressure in the studied substances in the range from 40 to 20 GPa in the course of about  $10^{-6}$  s and with a temperature not less than  $3-4 \times 10^3$  K. The following were among the investigated substances: sugar, benzene, ethanol, glycerin, benzene, acetone, paraffin and hexane. The research revealed that the formation of the diamond phase is common for all the organic substances, in the course of destruction of whose molecular structure under an adequately intensive dynamic load the presence of free carbon is ensured. However, despite a comparable total yield of condensed forms of carbon, which is largely determined by the balance of carbon participating in the transformations, the yield of the diamond phase differs substantially for different substances and is dependent on the individual properties of the investigated compounds. As a result of an increase in the amplitude of

loading of the mixture, which is realized in charges with an envelope of powerful explosive, independently of the filler the content of the diamond phase in the condensed products increases. This means that with a sufficiently great shock wave intensity there is total destruction of the organic substances and the diamond yield becomes nondependent on the initial molecular structure. Figure 1; references 12: 9 Russian, 3 Western.

UDC 533.951.8

**Electron Heating in Supercritical Shock Wave**

18620088a Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 11 Nov 88 (manuscript received 14 Aug 87,  
after revision 30 Dec 87) pp 1326-1334

[Article by M. A. Balikhin, N. L. Borodkova, O. L. Vaysberg, A. A. Galeyev, G. N. Zastenker, S. I. Klimov, M. N. Pozdrachev, A. A. Skalskiy, V. N. Smirnov and A. Yu. Sokolov, Space Research Institute, USSR Academy of Sciences]

[Abstract] The various mechanisms which may cause heating of solar wind electrons in a collisionless shock wave are reviewed. It is shown that there is still another source of free energy in supercritical shock waves: beams of reflected ions. A small fraction of this energy is adequate for heating electrons to the observed temperatures. Data are given on simultaneous satellite measurements of the distribution function of electrons, the magnetic field and intensity of plasma oscillations in the lower hybrid and ionosonic frequency ranges at the front of a circumterrestrial shock wave. The main heating of the electrons occurs only in a narrow jump region of the magnetic field at the wave front, whereas in the region of the shock wave foot, where the plasma turbulence level is already rather high, the heating is far less. The article gives the results of measurements of the parameters of plasma and fields at the front of the circumterrestrial quasiperpendicular, supercritical shock wave registered in one of its intersections by the "Prognoz-10-Intercosmos" satellite (Soviet-Czechoslovakian INTERSHOK program). It is shown that the main electron heating occurs in the immediate (several seconds) neighborhood of the magnetic field jump. A substantial contribution to this heating is from such processes as the adiabatic compression of plasma at the front and the interaction of electrons with large-amplitude electromagnetic oscillations. Figures 3; references 29: 9 Russian, 20 Western.

UDC 533.951

**Resonant Solitons of Electromagnetic Waves in Plasma With Admixture of Active Atoms**

18620088b Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 11, Nov 88 (manuscript received 8 Feb 88)  
pp 1400-1403

[Article by I. V. Bachin and Timurkhuyag Nerguy (Mongolia), Rostov State University imeni M. A. Suslov]

[Abstract] According to the theory of self-induced transparency, short impulses of electromagnetic waves can be propagated without distortions through a medium whose

atoms are described in a bilevel approximation. A study was made of the propagation of resonant electromagnetic waves in an active plasma medium, that is, in plasma with bilevel atoms. It is shown that the presence of a dispersing nonlinear medium (plasma) results in a change in the form and parameters of solitary impulses, whose formation in this case is related not only to the known mechanism described by S. L. McCall, et al. (PHYS. REV., Vol 183, p 457, 1969), but also the condition of absence of dispersive spreading of wave packets. A new mechanism of stabilization of resonant wave interaction becomes evident: an atom associated with the linear dephasing of an electromagnetic wave and a polarization wave in the presence of a plasma nonlinearity. As in the case of beam-plasma systems, the formation of resonant electromagnetic solitons occurs. The form and parameters of the solitary waves are determined by the dominant type of nonlinearity and dispersion. References 5: 4 Russian, 1 Western.

UDC 533.9

**Dielectric Permittivity Perturbations Associated With Transformation of Electromagnetic Wave by Small-Scale Plasma Inhomogeneities**

18620067a Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 10, Oct 88 (manuscript received 24 Aug 87,  
after correction 23 Mar 88) pp 1172-1179

[Article by V. V. Vaskov, Institute of Terrestrial Magnetism, the Ionosphere, and Radio-Wave Propagation, USSR Academy of Sciences]

[Abstract] Considering that conversion of an electromagnetic wave into plasma waves is a major source of plasma perturbations to be reckoned with in experiments on propagation of radio waves through the ionosphere, this phenomenon is analyzed and its consequences are evaluated by averaging and then solving the Maxwell equations for the electric field of a radio wave in a plasma with small density perturbations producing small-scale but prolate inhomogeneities. Calculations taking into account transverse and thermal effects yield the dielectric permittivity tensor of a perturbed plasma layer as well as analytical estimates of the anomalous absorption and the extra refraction of an ordinary radio wave within the resonance region, expansion of the perturbation region evidently preventing sharply localized perturbations of the dielectric permittivity and thus strong reflection of a radio wave by the perturbed plasma layer. References 10: 8 Russian, 2 Western.

UDC 533.9

**Fine Structure of Front of Quasi-Perpendicular Supercritical Collisionless Shock Wave**

18620067b Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 10, Oct 88 (manuscript received 13 Oct 87,  
after correction 20 Jan 88) pp 1192-1200

[Article by A. A. Galeyev, V. V. Krasnoselskikh and V. V. Lobzin, Institute of Terrestrial Magnetism, the Ionosphere, and Radio-Wave Propagation, USSR Academy of Sciences]

[Abstract] Existence of steady shock waves near the Earth without collisions and attendant dissipation but

with dispersion and nonlinearity playing competitively the dominant role in formation of the wavefront is considered, analysis of this hypothesis and its consequences being based on a model which describes quasi-perpendicular supercritical collisionless shock waves. The front of such a shock wave, according to this model, consists of four regions between the oncoming stream before it and steady flow behind it: a pedestal along which the oncoming stream is stalled by reflected waves, then a ramp along which the magnetic field builds up most steeply, then a region within which the magnetic field has a flat top, and then a region with ring-out oscillations of the magnetic field. The formation of such a shockwave is treated as a multistage evolutionary process, longwave plasma oscillations with negligible dispersion effects in the first stage being followed by whistlers within the dispersion range and the latter being followed by quasi-potential oscillations in the third stage. These, occurring within the ramp region, are shown to play an essential role in formation of the fine structure of the front of a supercritical shock wave. The authors thank M. A. Balikhin, O. L. Vaysberg, M. E. Gedalin, M. B. Isichenko, S. I. Klimov, A. S. Lipatov, M. N. Nozdachev and R. Z. Sagdeyev for helpful discussions. Figures 3; references 25: 19 Russian, 1 Hungarian, 5 Western (1 in Russian translation).

UDC 537.523

**Dynamics of High-Current Pulse Discharge in Air**  
18620067c Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 10, Oct 88 (manuscript received 6 Jul 87,  
after correction 14 Oct 87) pp 1222-1227

[Article by Yu. K. Bobrov, V. V. Vikhrev and I. P. Fedotov, All-Union Institute of Electrical Engineering imeni V. I. Lenin and Institute of Atomic Energy imeni I. V. Kurchatov]

[Abstract] High-current pulse discharge in air under atmospheric or higher pressure is analyzed on the basis of numerical simulation, considering that the glow region generally expands from the discharge center and forms a current channel behind the compression shock wave while the highly compressed gas heats up to high temperatures. The plasma in the current channel also heats up to high temperatures, but its density remains much lower than that of the quiescent gas. The gas heats up and becomes ionized within a zone enveloping the current channel. Calculations are based on a system of five equations of magnetohydrodynamics which take into account both conductive energy transfer by electrons and radiative energy transfer in the diffusion approximation as well as pressure and diffusion of the magnetic field. The electrical conductivity of air is described by the Soshnikov-Trekhov relation (1966). The equation of radiation diffusion has been solved in the approximation of three spectral groups, assuming that the absorption coefficient for each group does not depend on the frequency and is equal to the Planck

average. The results of numerical solution for appropriate initial and boundary conditions reveal a predominantly radiative energy transfer and a scattering of light by the electron concentration gradient responsible for the abrupt change of the refractive index along shadow traces on the envelope of the current channel, this phenomenon having been observed in Dolgov-Mandelstam (1953) and later experiments. The results of this analysis apply to  $10^3$ - $10^5$  A pulse discharges of  $10^{-4}$ - $10^{-1}$  ms duration. Figures 5; references 27: 16 Russian, 1 Western (in Russian translation).

UDC 533.933

**Cooling of Positrons by Electrons**  
18620067d Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 10, Oct 88 (manuscript received 11 Mar 88)  
pp 1274-1277

[Article by A. S. Aramonov and Ya. S. Derbenev, Scientific Research and Design Engineering Institute of Technology of Complete Electric Drive]

[Abstract] Cooling of positrons by electrons in a magnetic field is considered, much faster cooling of positrons than of heavy particles by electrons being feasible because the transverse motion of electrons and positrons is magnetically guided and their Larmor rotation can be resonant. The process is analyzed theoretically, assuming nonrelativistic motion of all particles and focusing on the most important, from the standpoint of fast cooling, slow collisions during which particles have time to rotate long enough for complete energy and momentum transfer. Calculations are made in a system of coordinates referred to the electron beam, in the nonrelativistic approximation of weak interaction with negligible electron-electron collisions. Four scalar products in the form of integrals are obtained on this basis, the friction force and the fluctuation force being each separately multiplied by the longitudinal component and the transverse component of the positron momentum. The diffusion coefficient for each component of the positron momentum is also expressed in the form of an integral. Initial noise in the homogeneous electron beam is assumed to be shot noise, and the electron-positron interaction path is assumed to be sufficiently short for longwave excitations due to electron-electron collisions not to become appreciably attenuated. For an estimation of the cooling time, both friction and fluctuation forces are evaluated in the two extreme cases of  $\omega_e t$  much smaller and much larger than unity ( $\omega_e$ , equal to square root of  $4\pi e^2 n/m$ ,  $e$  - electron charge,  $m$  - electron mass,  $n$  - electron concentration,  $t$  - time). References 12: 8 Russian, 4 Western.

UDC 534.221

**High-Temperature Acoustic Anomalies and Superionic Conductivity in Multicomponent Phosphate Glasses**  
18620096c Leningrad FIZIKA TVERDOGO TELA  
Vol 30 No 10, Oct 88 (manuscript received 26 Apr 88)  
pp 2981-2991

[Article by Yu. V. Ilisavskiy and L. A. Kulakova, Physical Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]



[Abstract] Experimental research on the acoustic properties of glasses in the range of medium and high temperatures is difficult due to high absorption. Most available data are therefore for low temperatures or low frequencies. An important variety of glasses is those with superionic conductivity or solid electrolytes. Mobile ions diffuse easily through the lattice of such glass and therefore considerable ionic conductivity already arises at room temperature. This article gives the results of study of the acoustic properties of niobium phosphate glasses of the system  $(M_2O)_x(P_2O_5)_y(Nb_2O_5)_{1-x-y}$ , where M: Li, Na, K, Rb. Glasses with  $Li_2O$  have clearly expressed conductivity and electrochromic properties. However, they have not been studied by acoustic methods. A study was made by optoacoustic and pulsed echo methods for measuring sound absorption, making possible substantial broadening of the range of acoustic frequencies (30-1500 MHz) in the temperature range 10-1500 K. This made it possible to define important characteristics of acoustic absorption by the lattice of multicomponent phosphate glass. These characteristics can be explained within the framework of a generalized model of two-level defects. Low-temperature relaxation is governed by tunneling processes, whereas in the high-temperature range absorption by the glass lattice is attributable to thermoactivation processes. The model also explains acoustic absorption of lithium by mobile ions. Figures 6; references 30: 22 Russian, 8 Western.

#### Predicting Sensitivity of Explosive Substances to Impact

18620070a Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 24 No 5, Sep-Oct 88 (manuscript received 13 Nov 86) pp 103-106

[Article by A. V. Velik and V. A. Potemkin, Chelyabinsk]

[Abstract] A statistical study aimed at predicting the sensitivity of explosive substances to impact was made on the basis of the pattern recognition theory, using DETERM, DREAM, and PRINCE programs written in algorithmic FORTRAN and BASIC for a YeS-1022 standard computer and an Elektronika DZ-28 microcomputer. Calculations were made for 78 organic substances (nitroamines, C-nitro compounds, N-nitro compounds) with already known sensitivity characteristics. The striker height  $H_{50}$  corresponding to a 50 pct probability of explosion served as measure of sensitivity and as criterion for grouping all substances into three classes:  $H_{50}$  smaller than 30 cm, 30-70 cm, larger than 70 cm. Five indicators were used for pattern recognition and sensitivity prediction: 1) excess of oxidizing substance  $OB_{100}$  "built into" a molecule per 100 g explosive substance, 2)  $e^{OB_{100}}$ , on account of  $H_{50}$  being a linear function of  $OB_{100}$ , 3) number K of groups encumbering the molecule of explosive substance, 4) modified branching index P, 5) type of compounds characterized by T equal to 1 for N-nitro compounds and to 0 for C-nitro

compounds, this indicator used only for simultaneous recognition of C-nitro compounds and nitroamines. Tables 1; references 4: 3 Russian, 1 Western (in Russian translation).

#### Measurement of Parameters of Dense Plasma Produced by Impact Compression of Porous Tin and Copper

18620070b Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 24 No 5, Sep-Oct 88 (manuscript received 9 Jun 86) pp 119-122

[Article by L. G. Bolkhovitinov and Yu. B. Khvostov, Moscow]

[Abstract] For an experimental study concerning production of dense plasmas of heavy metals by impact compression, 0.020 mm thick porous foils of Sn ( $0.45 \text{ g/cm}^3$ ) and Cu ( $0.36 \text{ g/cm}^3$ ) were compressed by plane shock waves through a 4 mm thick plate of plexiglass. The shock waves were generated by explosion of a cyclonite charge ( $1.76 \text{ g/cm}^3$ ) and the detonation cap. The parameters of the ensuing plasmas were determined from readings of the stagnation pressure, the impact velocity, and the return velocity. The rate of plasma expansion was monitored with a high-speed photographic camera. Up to 84 pct of porous solid Sn and up to 99 pct of porous solid Cu was found to transform into plasma within 0.010 ms under sufficiently high pressure build-up to 12 GPa and 24 GPa respectively and corresponding power build-up. Figures 1; tables 2; references 5: 3 Russian, 2 Western.

UDC 534.21.534.222.2

#### Strain Solitons in Nonlinearly Elastic Media Undergoing Phase Transition

18620048a Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 9, Sep 88 (manuscript received 3 Mar 88) pp 2844-2845

[Article by V. I. Serikov and S. V. Voronin, Lipetsk Polytechnic Institute]

[Abstract] Strain propagation during phase transition in ferroelectric and ferromagnetic materials with a quadratic strain dependence of the order parameter is analyzed for soliton solution to the corresponding system of two simultaneous equations of acoustics, the strain wave equation and the Ginzburg-Landau relaxation equation, such a solution in this case not being obtainable by linearization. With quadratic terms in the strain as well as quadratic terms in the order parameter included in the strain wave equation, a soliton solution is sought on a phenomenological basis. It is found, but only for materials with a positive nonzero ratio  $g/cG$  ( $g$ -striction coefficient,  $c$ -modulus of elasticity,  $G$ -nonlinear acoustic parameter). It is subsequently reduced to a set of five expressions: for the velocity and the width of a soliton,

both remaining finite, for the absorption coefficient, and for the amplitudes of both the strain and the order parameter. References 1: Russian.

UDC 533.95

**Characteristics of Drift Solitons in Plasma According to Results of Model Experiments With Fast-Rotating Shallow Water**

18620043b Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 9, Sep 88 (manuscript received 18 Jun 87,  
after correction 22 Mar 88) pp 1104-1121

[Article by S. V. Antipov, M. V. Nezlin, V. K. Rodionov, A. Yu. Rylov, Ye. N. Snezhkin, A. S. Trubnikov, and A. V. Khutoretskiy, Institute of Atomic Energy imeni I. V. Kurchatov and Astronomic Council, USSR Academy of Sciences]

[Abstract] Series of model experiments with drift solitons under hydrodynamic conditions, Rossby solitons in shallow water in fast-rotating vessels, have yielded results on the basis of which it is possible to predict their characteristics in a magnetized tokamak or cosmic plasma according to the theory of physical analogy. The analogy between Rossby waves and drift waves has been established theoretically by demonstrating that the fluctuating depth of shallow water and the fluctuating potential of a plasma, the latter proportional to the fluctuating plasma density (charge carrier concentration), are describable by the same dimensionless equation. An analysis of this equation, which indicates the possibility of balance between dispersion and scalar nonlinearity, is followed by an analysis of the experimental configurations. Monopole (anticyclone) and dipole Rossby solitons rotating as free vortices are described, also Rossby vortices in shallow water under counterflow conditions and non-Rossbyian helical vortex structures in differentially rotating shallow water. Finally, anomalous diffusion of a magnetized plasma is interpreted in terms of a vortex mechanism. Recent attempts by Sommeria, S. D. Meyers, H. L. Swinney, by P. S. Marcus, and by A. P. Ingersoll to simulate the Large Red Jupiter Spot vortex are deemed to be inadequate and not directly relevant. Figures 9; references 49: 29 Russian, 22 Western (1 in Russian translation).

UDC 533.951

**Autotuning of Magnetic Antenna to Resonance by Plasma of High-Frequency Discharge**

18620043a Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 9, Sep 88 (manuscript received 23 Dec 86,  
after correction 16 Dec 87) pp 1094-1098

[Article by G. A. Markov, Gorkiy State University imeni N. I. Lobachevskiy]

[Abstract] Experiments were performed with a small loop antenna inside a magnetic "race track" trap without rotational field transformation, for observation of its

behavior under conditions of high-frequency electrical breakdown of the ambient gas in a magnetic field. The discharge chamber was 4.5 m long, the inside diameter of its 100 cm long straight glass segments was 16 cm, the larger radius and the smaller radius of its toroidal glass segments were 40 cm and 3.7 cm respectively. The chamber was filled with air as plasma-generating gas under a pressure of 5 mm Hg. The longitudinal magnetic field with an induction of 270 G was uniform within plus or minus 10 percent. The loop antenna, serving as source of a high-frequency electric field, was made of copper wire 0.6 mm in diameter. Diagnostic exploration of the plasma was done with electric and magnetic probes. Electromagnetic radiation emitted by it was recorded in an S4-27 analyzer and measured with a P6-22 instrument antenna. As the amplitude of electric field intensity in the rarefied gas was raised sufficiently high, above 10 V/cm, a high-frequency discharge was triggered around the antenna and a flat long plasma column with a cross-section identical to that of the antenna propagated in the direction of the external magnetic field. The antenna tuned itself in one step to the oscillator and its power output increase by one order of magnitude. The author thanks A. G. Litvak, V. A. Mironov, and A. M. Sergeyev for stimulating discussions and helpful comments. Figures 4; references 11: 9 Russian, 2 Western.

**Mach Reflection of Conical Shock Waves in Condensed Medium**

18620056a Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 16, 26 Aug 88 (manuscript received  
22 Mar 88) pp 1448-1452

[Article by A. Yu. Logvenov, A. L. Misonochnikov and B. V. Rumyantsev]

[Abstract] Mach reflection of shock waves converging inside a metal cone made of copper and struck omnilaterally by a conical copper liner is analyzed, on the basis of numerical simulation with a Lagrangian finite-difference scheme approximating two-dimensional nonsteady-state equations of hydrodynamics on a triangular grid, in search of local theories most adequately describing flow in the vicinity of the triple point. Interpretation of the results in terms of shock polars indicates that most adequate is the three-shock theory with either one discontinuity of contact or a trail behind the triple point, depending on the initial wave parameters. As the specific solution to the corresponding system of equations is selected the one which yields the lowest pressure behind the front of the reflected shock wave. Figures 2; references 7: 6 Russian, 1 Western.

UDC 533.951

**Alfven Solitons and Shock Waves in Dissipative Plasma**

18620011b Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 7, Jul 88 (manuscript received 9 Apr 87, after  
correction 24 Sep 87) pp 886-888

[Article by Dzh. I. Dzhavakhishvili, Tbilisi State University]

[Abstract] Action of an Alfven pump wave on a dissipative magnetized plasma, a nonlinear process in the case of such a wave much stronger than the ponderomotive

force and the gaskinetic pressure, is described by a system of six dimensionless MHD equations which take into account finiteness of the Larmor radii and of the electrical conductivity. In the case of a finitely large ordinary Reynolds number, proportional to the product of Alfven speed and quiescent electrical conductivity, but with a dispersion effect much stronger than the dissipation effect this latter effect on the evolution of a soliton is described in the solution to that system of equations with additional two equations of the perturbation theory for solitons. An analysis of the solution indicates that an Alfven soliton attenuates at a rate which increases with decreasing Reynolds number and thus decreasing electrical conductivity of the plasma. In the case of equal magnetic electron and ion Reynolds numbers, moreover, the solution represents a shock wave with a front which is determined by dissipation. The author thanks N. L. Tsintsadze for discussion. References 5: 3 Russian, 2 Western (1 in Russian translation).

UDC 533.6.011

**Hypersonic Three-Dimensional Viscous Shock Layer at Blunt Body in Stream at Arbitrary Angle of Attack and Glancing Angle**

18620047 Moscow *TEPLOFIZIKA VYSOKIKH TEMPERATUR* in Russian Vol 26 No 4, Jul-Aug 88 (manuscript received 24 Apr 87) pp 751-758

[Article by A. I. Borodin and S. V. Peygin, Tomsk State University imeni V. V. Kuybyshev]

[Abstract] The theory of hypersonic or thin three-dimensional viscous shock layer is applied to hypersonic flow of a viscous compressible heat-conducting gas past a smooth blunt body at an arbitrary angle of attack and an arbitrary glancing angle, the problem generally reducing to a mathematically simple problem of the parabolic kind and having an asymptotically exact solution for flow of any viscous gas in the region between shock wave and body surface with very small to very large values of the Reynolds number. The gas is assumed to be homogeneous and the body surface is described by an equation in a Cartesian system of three generalized space coordinates, Rankin-Hugoniot boundary conditions are stipulated at the shock wavefront and a stagnation temperature but zero velocity are stipulated at the body surface. The system of four equations of flow in the shock layer, formulated in a curvilinear system of three generalized space coordinates and reduced to dimensionless form, is the asymptotic version of Navier-Stokes equations for the limiting case and represents a two-point boundary-value problem of the parabolic kind with an extra boundary condition. The latter can be used for determining the not apriori known deviation of the shock wave from the body surface. This system of equations, a nonlinear one, has been solved by introduction of new independent functions into each equation reducing them all to first-order equations. These were linearized and

then converted from partial differential to finite-difference equations with an implicit scheme. The solution was obtained by iterations. The results indicate that, for a body of a fixed shape, the distributions of pressure, friction coefficient, and heat transfer coefficient over its surface depend largely on both the angle of attack and the glancing angle. Figures 5; references 12: Russian.

UDC 534.24

**Decay of Noncoherent Field in Ocean With Large-Scale Surface Roughness**

18620010b Moscow *AKUSTICHESKIY ZHURNAL* in Russian Vol 34 No 4, Jul-Aug 88 (manuscript received 27 Jul 87) pp 588-592

[Article by A. V. Belousov and Yu. P. Lysanov, Institute of Acoustics imeni N. N. Andreyev, USSR Academy of Sciences]

[Abstract] An isotropic monochromatic point source of sound in an ocean with rough surface is considered, the surface roughness of the ocean being characterized by a scattering coefficient which is maximum in the direction of specular reflection. The acoustic field of this source is calculated in accordance with the theory of radiation transfer, the equation of radiation transfer being formulated for a surface layer-channel within which the speed of sound increases with increasing depth down to its lower boundary and then either remains constant at that maximum level or decreases with further increasing depth below it. The ocean bed is assumed to be ideally absorbing so that no energy is reflected back into the surface layer. Analytical solution of this equation yields the decay pattern of a noncoherent acoustic field with increasing horizontal distance from the source, namely the field intensity as a function of the radial coordinate and the glancing angle with absorption of sound contributing an exponential term. Figures 1; references 8: Russian.

UDC 534

**Fine Structure of Sound-Scattering Ocean Layers**

18620010c Moscow *AKUSTICHESKIY ZHURNAL* in Russian Vol 34 No 4, Jul-Aug 88 (manuscript received 11 Dec 87) pp 603-607

[Article by A. S. Borisov, V. S. Karpov, A. M. Kudin, and K. B. Topornin, Institute of Geochemistry and Analytical Chemistry imeni V. I. Vernadskiy, USSR Academy of Sciences]

[Abstract] Evolution of water turbulence regions in an ocean and formation of thin layers with almost identical density gradients, which had been discovered by holographic interferometry at upper and lower boundaries of such regions in the eastern part of the Atlantic Ocean during the scientific expedition of the "Academician Boris Petrov" research vessel and in prior laboratory experiments, were subsequently studied by acoustic



methods. Scans with sounding signals and analysis of the echo signals have revealed a relation between the fine structure of these sound-scattering layers and the fine structure of hydrophysical fields in the ocean. The authors thank G. I. Barenblatt and V. S. Velokon for valuable comments made during discussion of the results. Figures 2; references 11: Russian.

UDC 551.463.22

**Thermal and Dynamic Components of Short-Period Sound Velocity Fluctuations Near Ocean Surface**

18620010d Moscow *AKUSTICHESKIY ZHURNAL* in Russian Vol 34 No 4, Jul-Aug 88 (manuscript received 7 May 87) pp 638-643

[Article by A. S. Zapevalov and G. N. Khristoforov, Institute of Marine Hydrophysics, UkSSR Academy of Sciences]

[Abstract] Short-period sound velocity fluctuations near the ocean surface are analyzed for a quantitative relation between their thermal and dynamic components, which depend on the amount of solar heat absorbed by the ocean surface layer and by the velocity of ripple-causing wind respectively. The analysis is based on experimental data pertaining to various regions of the Pacific Ocean and on theoretical calculation of the fluctuation spectra. The structure of hydrophysical fields indicates the conditions under which and the ranges within which either one or the other fluctuation component will be predominant. Figures 3; references 6: 4 Russian, 2 Western (1 in Russian translation).

UDC 551.463.21

**Theoretical Study Concerning Depth Dependence of Oceanic Noise**

18620010e Moscow *AKUSTICHESKIY ZHURNAL* in Russian Vol 34 No 4, Jul-Aug 88 (manuscript received 3 Aug 87) pp 711-716

[Article by V. M. Serbin]

[Abstract] The depth dependence of the intensity of oceanic noise is analyzed and evaluated theoretically, an ocean being treated as a multilayer kind of nonhomogeneous medium and a uniform distribution of noise sources on its surface being assumed so that the characteristics of the noise field are functions of the depth coordinate only. They are calculated by the Monte Carlo method, taking into account Fresnel reflection by the ocean bed as well as scattering by the surface, in successive layers, and by internal waves. Numerical results agree with experimental data for the 500 Hz band, while at frequencies below 300 Hz noise sources not associated with wind become the principal contributor to the noise field and thus the cause of significant error of calculations based on the given

model. The author thanks B. F. Kuryanova and B. I. Klyachina for interest and helpful discussions. Figures 2; references 14: 9 Russian, 5 Western.

UDC 551.463

**Level of Oceanic Noise Within Angular Range of Refraction Minimum**

18620010f Moscow *AKUSTICHESKIY ZHURNAL* in Russian Vol 34 No 4, Jul-Aug 88 (manuscript received 13 May 87) pp 732-733

[Article by A. V. Belousov and A. V. Furduev, Institute of Acoustics imeni N. N. Andreyev, USSR Academy of Sciences]

[Abstract] The level of oceanic noise, anisotropic in a deep ocean with an underwater sound channel and under these conditions characterized by existence of a refraction minimum within a small range  $A_0$  of angles from the horizontal, is usually estimated on the basis of readings taken by a highly directional receiver antenna within that range of angles. The accuracy of such an estimate is determined not only by the sensitivity of the antenna within the side lobes of its radiation pattern but also by scattering of noise of inhomogeneities within the medium. The effect of "gating" the reflection minimum can be accounted for on the basis of a simple model, that of an infinitely large homogeneous ocean layer with consideration of only two scattering intensities, at the ocean surface and at the ocean bed respectively. Their sum, multiplied by  $2\pi \sin A_0$  and by the ratio of scattering coefficient to absorption coefficient, yields the intensity of scattering by volume inhomogeneities. Figures 2; references 3: Russian.

UDC 534.222.2

**Exponential Profile of Shock Wave in Fluid**

18620010g Moscow *AKUSTICHESKIY ZHURNAL* in Russian Vol 34 No 4, Jul-Aug 88 (manuscript received 13 Jul 87) pp 750-752

[Article by Yu. V. Petukhov, Institute of Applied Physics, USSR Academy of Sciences]

[Abstract] It is theoretically demonstrated that the exponential profile of a shock wave immediately behind its front in a slightly compressible fluid represents the "limiting" solution to the Kirkwood-Bethe equation for the rate of change of pressure at the boundary between that fluid and gaseous explosion products. The initially exponential pressure fall behind the front of a shock wave is subsequently shown to be a consequence of a strong impact being of short duration, within which the cavity formed by the departing compression wave has hardly time to expand so that the pressure distribution during the transient period depends on neither velocity nor its rate of change. References 13: 8 Russian, 5 Western (1 in Russian translation).

**Radiation Emission by Excited Ar-Complexes and Kr-Complexes in Shock Waves**

18620007b Novosibirsk FIZIKA GORENIYA I  
VZRYVA in Russian Vol 24 No 3, May-Jun 88  
(manuscript received 3 Jun 86) pp 113-115

[Article by N. D. Kurmey and V. G. Nazarenko, Kiev]

[Abstract] An experimental study was made concerning radiation emission by partly ionized argon and krypton in a reflected shock wave and during discharge through a supersonic nozzle. For the experiment was used a shock tube 96 mm in diameter with a flat 30 deg diverging and deflecting nozzle, hydrogen serving as propellant. Temperature, pressure, and Saha ionization degree before the nozzle were: 11850 K, 4.8 atm, 0.076 (Ar) and 11800 K, 6.3 atm, 0.11 (Kr). Radiation spectra were measured simultaneously at four distances (4, 10, 20, 40 mm) from the critical nozzle section, through light guides feeding the radiation to an ISP-51 spectrograph, with the arc spectrum of iron serving as the interpretive one. Analysis of the spectra by photographic photometry, combined with temperature estimates on the basis of shock wave and nozzle readings, has yielded a pattern which fits the diffusion theory of recombinational relaxation. The range of energy through which an electron passes while recombining with an ion consists of a quasi-continuous spectrum which corresponds to high-excitation states in atoms and a discrete spectrum which corresponds to low-excitation states in atoms in quasi-equilibrium with the ground state. The temperature dependence of the radiation intensity at the various lines, a different one of each line and changing along the nozzle, cannot be explained entirely by the impact-radiation theory but by also considering the Penning process. Figures 3; references 7: 4 Russian, 3 Western.

**Study of Decomposition in Detonation Wave by Isotopic Method**

18620007c Novosibirsk FIZIKA GORENIYA I  
VZRYVA in Russian Vol 24 No 3, May-Jun 88  
(manuscript received 11 Mar 88) pp 121-122

[Article by V. F. Anisichkin, B. G. Derendyayev, V. A. Koptuyug, I. Yu. Malkov, N. F. Salakhutdinov, and V. M. Titov, Novosibirsk]

[Abstract] An experiment was performed with detonation of a TNT-RDX mixture,  $^{12}\text{C}$  carbon of the methyl group having been replaced with  $^{13}\text{C}$  tracer in 58 percent of all TNT molecules and the tracer content in the entire charge including the RDX booster being 5.7 percent. The decomposition process following detonation in a helium atmosphere was monitored by mass-spectrometry on the basis of  $^{13}\text{C}/^{12}\text{C}$  isotope ration in samples of the gaseous reaction products and in the carbon condensate, rather than by complete mass analysis. This ratio was found to be 0.04, 0.048, and 0.073 in  $\text{CO}$ ,  $\text{CO}_2$ , and  $\text{C}_2\text{H}_4$  respectively, the higher tracer content in  $\text{C}_2\text{H}_4$  being probably attributable to its preferential production from TNT molecules. References 4: 1 Russian, 3 Western (1 in Russian translation).

**Possibility of Identifying Shock-Wave Processes**

18620007d Novosibirsk FIZIKA GORENIYA I  
VZRYVA in Russian Vol 24 No 3, May-Jun 88  
(manuscript received 13 Nov 86) pp 106-112

[Article by Yu. N. Kuznetsov, Novosibirsk]

[Abstract] Flow induced in a metal by interaction of a shock wave and cavities between parallel walls formed during explosion welding is analyzed on the basis of semiempirical relations supplementing experimental data. An experiment was performed with  $60 \times 50 \times 50 \text{ mm}^3$  and  $60 \times 80 \times 50 \text{ mm}^3$  large blocks of St45 carbon steel, their surfaces having been ground. First three and four of them were placed on a 3.5 mm thick base of strip steel for simultaneous impact, the clearance between them being 0.2, 0.6, 0.4 mm and 0.5, 0.6, 0.8, 1.0 mm respectively. They were struck from above by a 3 mm thick swinging copper plate so that an impact of respectively 9-11 GPa and 14-16 GPa was produced, the initial elevation of the copper plate having been selected for uniform impact across all steel blocks. Measurements of the wave parameters and microstructural examination of the blocks provided sufficient data for identification, analysis, and evaluation of processes occurring in the steel upon impact. Figures 7, tables 1; references 35: 26 Russian, 9 Western.

**Josephson Effect in Granulated Superconductors**

18620112a Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 49 No 2 25 Jan 89 (manuscript  
received 25 Nov 88) pp 86-89

[Article by A. F. Volkov, Radio Engineering and Electronics Institute, USSR Academy of Sciences]

[Abstract] A superconducting ceramic with high  $T_c$  is a granulated system with Josephson transitions (JT) between the granules. Josephson effects (coherent response to the magnetic field and a variable signal) are observed in ceramics. In some studies it has been postulated that one or more JT are operative, but such an assumption is likely only near  $T_c$  when fluctuations suppress superconductivity in JT and percolation effects are significant. Far from  $T_c$ , where the mentioned effects were also observed, the current flows through many DT and the correctness of this assumption is questionable. This article describes a model of a granulated superconductor with JT having different critical currents  $I_c$ . The considered system is described by the same equations as the equations for inhomogeneous tunnel JT. It is established that the characteristic dimension of the constriction in which coherent effects can be observed can be extremely great. The shape of the volt-ampere characteristic is also found with  $\delta I_c$  taken into account. This is demonstrated for a case when the granules form a quadratic lattice with JT at the points of contact of granules. Shapiro bands can be observed in a band of great but finite length, whereas magnetooscillations can be observed in an infinite band. Figure 1; references 8: 4 Russian, 4 Western.

**Superconductivity at Temperatures Above 100 K in Bi-Ca-Sr-Cu-O System**

18620112b Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 49 No 2, 25 Jan 89 (manuscript  
received 5 Dec 88) pp 93-95

[Article by A. G. Sarkisyan, V. M. Arutyunyan, R. S. Akopyan, R. S. Vartanyan, E. V. Putnyn, N. M. Dobrovolskiy and S. G. Gevorkyan]

[Abstract] There have been many recent communications on the detection of superconductivity in the metal-oxide ceramic system Bi-Ca-Sr-Cu-O at temperatures below 120 K. A study was made of the temperature of transition into a superconducting state of samples of this system as a function of composition and thermal processing conditions. Two series of samples were investigated. Their compositions are described by the formulas:  $Ba_2Ca_xSr_{3-x}Cu_2O_8$  and  $BiCa_xSr_{2-x}Cu_3O_8$ . The samples were synthesized by standard solid-phase powder technology. The initial materials used were bismuth and copper oxides and strontium and calcium carbonates. An x-ray phase analysis was made of the synthesized samples. At least three tetragonal phases were discovered. It was found that in many samples of bismuth ceramics in

addition to the main superconducting transition at about 80 K there is a superconducting transition in the temperature range 100-130 K and a diamagnetic transition at temperatures greater than 260 K which may be caused by the presence of a new high-temperature superconducting phase. The diamagnetism discovered at room temperature warrants further attention. Figures 3; references 6: 1 Russian, 5 Western.

**'Ferroelectric' Anomalies and Superconductivity in Metallic Oxide Compounds**

18620112c Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 49 No 2, 25 Jan 89 (manuscript  
received 12 Dec 88) pp 102-105

[Article by A. S. Shcherbakov, M. I. Katsnelson, A. V. Trefilov, N. L. Sorokin, V. Ye. Startsev, E. G. Valiulin, V. P. Dyakina and V. L. Kozhevnikov, Atomic Energy Institute imeni I. V. Kurchatov; Electrophysics Institute, Ural Department, USSR Academy of Sciences; Physics of Metals Institute, Ural Department, USSR Academy of Sciences]

[Abstract] An unusual phenomenon, "ferroelectric" anomalies (FEA), coexisting with metallic conductivity, was discovered in an investigation of the high-frequency properties of conducting metallic oxide compounds belonging to the class of high-temperature superconductors (HTSC) (A. S. Shcherbakov, et al., PISMA V ZhETF, 46, 111, 1987; FMM, 64, 735, 1987; FMM, 742, 1987). A study was made of the correlation between FEA and the superconducting characteristics of the systems  $YBa_2Cu_3O_{6+x}$ , YBCO, and  $La_{2-x}Sr_xCuO_4$ , LSCO. The properties of these semiconductors are discussed in detail. It is shown that the correlation between FEA and superconductivity is probably determined by an influence on the processes of setting-in of coherence in a system of Cooper pairs rather than on the energy characteristics of individual pairs. The correlation between the blurring of superconducting transitions and the resonance frequencies of microwave field absorption are discussed. Figures 3; references 11: 8 Russian, 3 Western.

**Spatial Distribution of Magnetic Induction Near Permanent Magnet and Attraction 'Effect' of High-Temperature Superconductor to Magnet Poles**

18620112d Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 49 No 2, 25 Jan 89 (manuscript  
received 16 Dec 88) pp 111-113

[Article by E. A. Vasilyev, Solid State Physics and Semiconductors Institute, Belorussian Academy of Sciences]

[Abstract] During the past year communications have appeared on the capacity of some samples of high-temperature superconductors (HTSC) of yttrium and



thallium systems to be attracted to a magnet. Such a phenomenon of attraction of samples of HTSC in a superconducting state to the pole of a magnet having the configuration of a tetrahedral prism was observed. In this case the HTSC sample was attracted to the pole of a magnet without a gap. A. M. Hermann, et al. assert that the observed phenomenon cannot be explained solely on the basis of the Meissner effect and they propose explanations based on the concept of "programmable" capture of the magnetic flux in a superconductor. They postulate the coexistence of superconducting and ferromagnetic phases or the coexistence of ferro- and diamagnetism in a single-phase HTSC. However, an analysis revealed that all the observed cases of "anti-Meissner" behavior are attributable to the nature of distribution of magnetic field induction near the poles of a permanent magnet. In all cases the capture of the magnetic field occurs with the formation of regions with a minimum of magnetic induction near the poles of permanent magnets. An analysis revealed that it is caused only by the presence of the ordinary Meissner effect in a magnetic field of the corresponding configuration and can be observed in superconductors of the first kind in the region of helium temperatures. Figures 2; references: 2 Western.

**Resonance-Percolation Trajectories (RPT) as High-Temperature Superconducting Channels in Thin Films of Metallic Oxides**

18620112e Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 49 No 2, 25 Jan 89 (manuscript  
received 22 Dec 88) pp 116-119

[Article by V. Ya. Furpichenkov, Novocherkassk Polytechnic Institute imeni S. Ordzhonikidze]

[Abstract] One of the main problems in high-temperature superconductivity (HTSC) remains unsolved: what model of superconductivity of local pairs adequately describes HTSC in known metallic oxides. This is attributable to the fact that experimentally it is extremely difficult to determine the value of the  $t/U$  parameter characterizing the bonding strength. Accordingly, a search was made for the conditions under which superconductors with different bonding strengths behave qualitatively differently. The search was made applying the concepts of resonance-percolation trajectories (RPT) developed by I. M. Lifshits, et al. (ZhETF, 77, 989, 1979; 83, 2362, 1982). One of the possibilities of differentiating superconductors with respect to bonding strength, based on the dimensional effect arising in systems of finite dimensions along the direction of flowing of the superconducting current (in thin monocrystalline films with a thickness  $L$  of about  $1 \mu\text{m}$ , or HTSC crystallites of ceramics with the characteristic dimension  $L$ ), was examined. The example used was  $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ . Formulas are derived which demonstrate the possibility of

existence of a dimensional effect in thin superconducting films which is qualitatively different for cases of strong and weak bonding strength. References 7: 6 Russian, 1 Western.

**Chemical Nature of Pairing of Holes in High-Temperature Superconductors**

18620112f Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 49 No 2, 25 Jan 89 (manuscript  
received 27 Dec 88) pp 119-121

[Article by I. Ye. Dzyaloshinskiy, Theoretical Physics Institute imeni L. D. Landau, USSR Academy of Sciences]

[Abstract] During the past year experimental material has been accumulated which is indicative of an oxygen-hole nature of high-temperature superconductivity (HTSC) when the current carriers are p-holes localized for the most part in  $\text{O}^-$  ions. Such a mechanism can operate not only in substances with  $\text{CuO}_2$  layers, but also in compounds not containing any copper. In this case magnetic properties will be secondary, in any case not playing the main role in the pairing process. This thought was recently clearly expressed by J. E. Hirsch. He proposed a universal mechanism of local pairing of p-holes due to the polarization created by a pair in one  $\text{O}^-$  ion, that is, by exchange of a local dipole (for the most part, electron) mode. The corresponding formulas, written in the Migdal approximation, will not differ from the results of a recent study by Eliashberg, where the exchange of several local Einstein (oxygen) modes was taken into account. This article gives qualitative considerations in support of Hirsch, relying on the properties of oxygen and its atomic and molecular ions in the gas phase. It is made clear that such a mechanism has a purely electron (chemical) nature. This is based on the fact that in the gas phase there are reactions of the " $\text{O}^-$  radical  $\rightarrow \text{O}_2^-$  peroxide  $\rightarrow \text{O}^-$  ion +  $\text{O}_2$  molecule" type. Figures 3; references 5: 3 Russian, 2 Western.

UDC 537.312.62

**Superconducting Helicoid: Alternative to Ordinary Superconducting Windings**

18620115 Moscow DOKLADY AKADEMII NAUK  
SSSR in Russian Vol 303 No 6, Dec 88 (manuscript  
received 10 Sep 87) pp 1366-1370

[Article by V. Ye. Keylin, I. A. Kovalev, N. F. Kopeykin, S. L. Kruglov, N. A. Lavrov and D. B. Pavin, Atomic Energy Institute imeni I. V. Kurchatov, Moscow]

[Abstract] A superconducting helicoid is proposed as an alternative to superconducting windings. Superconducting helicoids have the following advantages: high current density; good repetition of limiting currents and stability of operation up to this level; acceptable rate of current entry; optimal current distribution in helicoid; high mechanical strength, making it possible to fabricate a SC

magnet of complex configuration; simultaneity of return of helicoid to a normal state, increasing reliability in emergency situations; simple and convenient design, in which it is easy to realize low inductance, favoring energy output and with a high current density, to develop a cooling surface. It is emphasized that only magnets with a stationary operating mode are pertinent because electrodynamic losses with entry of the current into the helicoid are appreciably greater than in ordinary windings and in order of magnitude are equal to the magnetic energy stored in the winding. There are several ways that a helicoidal design can be used: in large stationary SC magnets, including those of a cylindrical configuration, or SC helicoids on the basis of promising, including high-temperature superconducting materials having high critical parameters but which are brittle, making fabrication of wire from them difficult. Such SC helicoids would make it possible to obtain stronger magnetic fields with a lesser thickness of the winding. Figures 4; references: 4 Russian.

**Influence of Infrared Radiation on Critical Current of Josephson Tunnel Junction**

18620078e Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 11, Nov 88 (manuscript received 24 May 88) pp 331-340

[Article by S. V. Levitskiy, Moscow Institute of Steel and Alloys]

[Abstract] The influence of a variable electromagnetic field on the critical current of a superconducting tunnel junction is examined. Computations were made using the microscopic method developed for research on a superconductor-semiconductor-superconductor system in which the finite dimensions of the tunnel barrier are taken into account. Specifically, the behavior of a superconducting tunnel junction irradiated by electromagnetic waves with a frequency exceeding the inverse "tunneling time" of electrons was investigated. It was found that as a result of exponential enhancement of the external field inside the barrier there should be a strong change in the critical current of the junction. Depending on the directivity of the variable electrical field there can be both an increase and a nonmonotonic decrease in the critical current with an increase in the intensity of irradiation. References 14; 13 Russian, 1 Western.

**Inelastic Relaxation of Electrons in Superconductor-Normal Metal Microjunctions**

18620078f Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 11, Nov 88 (manuscript received 26 May 88) pp 341-355

[Article by V. A. Khlus, Monokristallreaktiv Scientific Production Association]

[Abstract] The nonlinear conductivity of microjunctions of the ScN type between a superconductor and a normal metal in the region of voltages considerably exceeding

the superconducting energy gap is examined. With such voltages the nonlinearities of the volt-ampere characteristic are related for the most part to the contribution to the current from inelastic electron-phonon scattering. It is assumed that the junction micronarrowing is considerably less than the elastic impurity length for the free path of electrons, the inelastic electron-phonon interaction length and also the superconduction coherence length. The form of the phonon conductivity characteristics and the second derivative is essentially dependent on the value of the electron reflection coefficient  $R$  at the NS boundary. A strong temperature dependence of the second derivative was found below the critical temperature of the superconductor with an adequately high  $R$  value and also under the condition that the Eliashberg electron-phonon interaction function has peaks whose width is comparable in value to the energy gap. Figures 5; references 27: 21 Russian, 6 Western.

**Polarization-Optical Contrast and Twin Domain Structure of Monocrystals of High-Temperature Superconductors**

18620078g Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 11, Nov 88 (manuscript received 27 May 88) pp 356-364

[Article by D. Ye. Batova, V. K. Vlasko-Vlasov, V. A. Goncharov, G. A. Yemelchenko, M. V. Indenbom and Yu. A. Osipyan, Solid State Physics Institute, USSR Academy of Sciences]

[Abstract] In the study of high-temperature superconductors an analysis of the twin structure and a study of its correlation to the electrical and magnetic parameters of crystals are exceedingly important. The most complete information on the twin structure can be obtained by the polarization-optical method based on the effect of a change in light polarization with reflection from an anisotropic medium. Accordingly, the polarization-optical contrast in reflected light in twins was investigated in the monocrystals  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  and  $\text{GdBa}_2\text{Cu}_3\text{O}_{7-x}$ . A transmission electron microscope was used in analysis of the characteristics of contrast arising in the presence of narrow (thinner than the wave length of light) twin domains. In broad domains the phase shift was measured for waves with different polarizations with reflection from the basal and end (containing the  $c$  axis) faces of the monocrystals. The phase shift values reveal a strong anisotropy of optical conductivity ( $\sigma$ ) with a preferred direction along CuO chains, which may be evidence supporting a quasi-one-dimensional character of  $\sigma$  in monocrystals 1-2- 3. Figures 6; references 20: 11 Russian, 9 Western.

**IR Reflection and Raman Light Scattering Spectra of Superconducting Compounds in Bi-Sr-Ca-Cu-O System**

18620087b Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 9, 10 Nov 88 (manuscript received 12 Sep 88) pp 488-490

[Article by O. V. Kosogov, M. V. Belousov, V. A. Vasilyev, V. Yu. Davydov, Kim Gvan De, A. A. Kopylov, V. D. Petrikov and V. V. Tretyakov, Leningrad Electrotechnical Institute imeni V. I. Ulyanov (Lenin);

Physical Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences; Physics Scientific Research Institute, Leningrad State University]

[Abstract] Data are given on the IR reflection and Raman light scattering of ceramic samples and monocrystals of the Bi-Sr-Ca-Cu-O system in which high-temperature superconductivity (HTS) was recently discovered. The investigated ceramic samples were prepared by the solid-phase synthesis of a mixture of oxides (nitrates) of the initial composition Bi:Sr:Ca:Cu = 2:2:1:2 at 850-870°C in the air and had a superconductivity with a transition temperature  $T_c = 88$  K in the presence of a high-temperature phase with  $T_c = 100$  K. An x-ray microanalysis revealed the composition of this ceramic. Monocrystals measuring  $2.4 \times 1.4 \times 0.02-0.06$  mm with a c-axis perpendicular to the surface were grown with slow cooling of the partially fused mixture of initial components and the composition was determined; it did not have superconductivity. The Raman light scattering spectra were excited by an argon laser (wavelength 514.5 nm) and were registered by a spectrometer with the sample at room temperature. The reflection spectra were measured in the frequency range 100-700  $\text{cm}^{-1}$  using a Fourier spectrometer and in the frequency range 300-4000  $\text{cm}^{-1}$  with a spectrophotometer. The polarizations of the oscillations 460 and 630  $\text{cm}^{-1}$  were determined and the frequencies of the plasma oscillations and the width of the superconducting gap  $2\Delta = 250$   $\text{cm}^{-1}$  were estimated. Figures 2; references 5: 1 Russian, 4 Western.

#### Possible Analogies Between Superconductor Perovskites and Superconductors With Heavy Fermions

18620087c Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 9, 10 Nov 88 (manuscript received 29 Sep 88) pp 502-504

[Article by A. M. Tselik, Theoretical Physics Institute imeni L. D. Landau, USSR Academy of Sciences]

[Abstract] It was postulated by N. M. Plakida, et al. (EUROPHYS. LETT., 4, 1309, 1987) and J. R. Hardy, et al. (PHYS. REV. LETT., 60, 2191, 1988) that a high  $T_c$  value in superconductor perovskites is attributable to a strong electron-phonon bond, which in turn arises due to the strong deformation susceptibility of two-hole oscillators. Although this appears to be entirely sound, there is a need for supplementing their findings and drawing some analogies, for example, with superconductors with heavy fermions. The mentioned authors did not make allowance for the influence of electrons on the tunneling of an ion from hole to hole. Since the amplitude of the barrier is evidently low, n-type electrons can considerably "assist" tunneling, reducing the height of the barrier, and this circumstance completely changes the entire physical picture of the effect. A clarification of this picture is presented by application of a high-temperature model proposed by G. M. Vujcic, et al. (PHYS. LETT.,

A, 73, 439, 1979; J. PHYS., C, 14, 1981) for describing electron-phonon interaction in a highly anharmonic crystal, to which is added a term describing ion tunneling from hole to hole with the participation of n-type electrons. Formulas are derived for a more precise description of the interaction between electrons and anharmonic phonons. References: 10 Western.

#### New Data on Dependence of Critical Temperature on Oxygen Content in Superconducting Compound $\text{YBa}_2\text{Cu}_3\text{O}_x$

18620079c Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 8, 25 Oct 88 (manuscript received 22 Sep 88) pp 449-452

[Article by I. V. Aleksandrov, A. B. Bykov, I. P. Zibrov, I. N. Makarenko, O. K. Melnikov, V. N. Molchanov, L. A. Muradyan, D. V. Nikiforov, L. Ye. Svistov, V. I. Simonov, S. M. Chigishov, A. Ya. Shapiro and S. M. Stishov, Crystallography Institute imeni A. V. Shubnikov, USSR Academy of Sciences]

[Abstract] A study was made of the superconducting and structural properties of the compound  $\text{YBa}_2\text{Cu}_3\text{O}_x$  with different oxygen contents. In contrast to earlier studies, this investigation was made using monocrystalline samples. The crystals were grown from a nonstoichiometric melt. About 200 crystals with a total mass about 70 mg with a mean size  $1.5 \times 1.5 \times 0.03$  mm were used in the experiments. All crystals had tetragonal symmetry. The selected crystals were placed on the balance of a thermogravimetric unit and reduced to a constant temperature in an oxygen atmosphere at a pressure of 1 atm and a temperature 723 K before cooling at a rate of about 1 degree per minute. The mass increase of the crystals in the course of their oxygen saturation corresponded to a concentration change of about  $\Delta x = 0.664$ . An x-ray structural analysis revealed the composition of the initial and oxygen-saturated samples. For "saturated" crystals  $x = 7.0$ . Samples with intermediate oxygen contents were also obtained. The oxygen concentration corresponding to a transition of the crystals to a tetragonal phase was dependent on the technology used in obtaining the samples. The oxygen distribution in the entire range of concentrations (other than  $x = 7$ ) is extremely nonuniform. The dependence  $T_c(x)$  was determined; it has a clearly expressed plateau at  $T_c = 55-65$  K, for which possible explanations are advanced. The superconducting properties at  $x$  less than 6.5 have an irregular character and are extremely sensitive to the prehistory of the sample. Figures 3; references 4: 2 Russian, 2 Western.

#### Energy Gap in $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ Monocrystals With Different Oxygen Content

18620079d Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 8, 25 Oct 88 (manuscript received 2 Sep 88) pp 457-460

[Article by A. P. Volodin, B. Ya. Kotyuzhanskiy and G. A. Stepanyan, Crystallography Institute imeni A. V. Shubnikov, USSR Academy of Sciences; Moscow Institute of Steel and Alloys]

[Abstract] A study was made of the energy gap  $\Delta$  and its



spatial distribution in monocrystals of the HTS (high-temperature superconductor)  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  with different oxygen contents and the relationship between  $\Delta$  and the temperature of the superconducting transition was determined. The monocrystals were thin, shiny blackish platelets measuring  $1 \times 1 \times 0.03$  mm. The HTS energy gap was determined from the volt-ampere characteristic (VAC) obtained using a scanning tunnel microscope (STM). Due to the unique spatially local character of the measurements the STM made it possible to ascertain the energy gap value along the surface of the superconducting monocrystals. Tunnel measurements were made in the central undamaged part of the monocrystal at  $T = 4.2$  K. An appreciable asymmetry of the VAC, registered at different temperatures, was observed; the nature of this phenomenon remains unclear. The results are approximated by a linear dependence:  $2\Delta_{\text{mean}} = 4.4 \text{ kT}_c$ . Figures 4; references 7: 3 Russian, 4 Western.

#### High-Temperature Superconductivity in Multiphase Ceramic Samples of Bi-Ca-Sr-Cu-O System

18620094a Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 19, 12 Oct 88 (manuscript received  
16 May 88) pp 1770-1772

[Article by A. G. Merzhanov, S. V. Lysikov, M. D. Nersisyan, I. P. Borovinskaya, Yu. G. Morozov, Ye. A. Chernov and V. I. Ponomarev, Structural Macrotechnology Institute, USSR Academy of Sciences]

[Abstract] Earlier studies reported on synthesis of superconductors in the system Bi-Sr-Ca-Cu-O with a temperature of disappearance of resistance 75-85 K. A number of samples with the general formula:  $\text{Bi}_y\text{Sr}_u\text{Ca}_w\text{Cu}_v\text{O}_x$ , where  $y, u, w = 1-3$ ;  $v = 1-2$ , were investigated. The synthesis was carried out in a self-propagating high-temperature synthesis mode with further thermal processing of the products under conditions close to fusion or with ordinary furnace technology. Appropriate reagents (oxides, peroxides, carbonates) with a content of the main substance not less than 99 percent were used in the synthesis. Synthesis with furnace technology was in two steps at temperatures  $780^\circ\text{C}$  for several hours and at temperatures  $840-880^\circ\text{C}$  for one hour. In both cases the product was obtained in the form of a molten low-porous black mass. An x-ray analysis of layered platelets of matter revealed the presence of several phases with tetragonal and rhombic crystal systems. Two tetragonal modifications were identified. Most of the investigated samples had superconductivity with a transition temperature above the boiling point of liquid nitrogen. Data were obtained on the dependence of resistivity and susceptibility for samples of different composition on temperature. There is an improvement in superconductivity with an increase in the ratio  $w/u + v$  (with an increase in the number of copper atoms in comparison with the total number of atoms of alkali earth metals). Figure 1; references 4: 1 Russian, 3 Western.

#### Superconducting Interference Magnetometers and Magnetic Screens From $\text{YBa}_2\text{Cu}_3\text{O}_7$ Ceramic Operating at Nitrogen Temperatures

18620094b Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI  
Vol 14 No 19, 12 Oct 88 pp 1791-1794

[Article by V. N. Zavaritskiy and N. V. Zavaritskiy, General Physics Institute, USSR Academy of Sciences, Moscow]

[Abstract] An earlier article by the authors (PISMA V ZhETF, Vol 46, No 11, pp 469-471, 1987) described a superconducting interferometer (VCh-SKVID) operating at nitrogen temperatures. This article reports on the results of investigation of the characteristics of this instrument with respect to its use as a magnetometer and describes its use in study of the characteristics of superconducting magnetic screens from  $\text{YBa}_2\text{Cu}_3\text{O}_7$ , a ceramic at 77 K. The developed magnetometers can sustain multiple thermal cycling and have characteristics stable over a long period of time (up to eight months). The characteristics of the magnetometers were studied in both a geometry of a ring with a weak link and as "two-hole" instruments. The "two-hole" instrument, for example, makes it possible to study the magnetic characteristics of samples placed in the large aperture of the instrument. A magnetic field was generated by a long solenoid and the results of investigation of special ceramic magnetic screens (which are described) for such a field are given. The field within the screen retains its strength with an accuracy not less than  $10^{-7}$  gauss with a change in the external field by 1-9 gauss. For magnetic fields exceeding the field of total screening the field penetrates within the screen. The study revealed the possibilities of using a nitrogen SKVID both for measurements of the external magnetic field and in magnetic research when the investigated object is in the large interferometer aperture and is separated from external magnetic fields by a superconducting screen. Figures 2; references 5: 4 Russian, 1 Western.

UDC 537.312.62

#### Structure of Phase $\text{Y}_1\text{Ba}_2\text{Cu}_3\text{O}_{6.5+y}$ and Superconductivity

18620096d Leningrad FIZIKA TVERDOGO TELA in Russian  
Vol 30 No 10, Oct 88 (manuscript received  
15 Mar 88) pp 2905-2909

[Article by M. V. Krasinkova and B. Ya. Moyzhes, Physical Technical Institute, USSR Academy of Sciences, Leningrad]

[Abstract] In the structure of  $\text{Y}_1\text{Ba}_2\text{Cu}_3\text{O}_{6.5+y}$  there are three layers  $^{11}\text{CuO}_2\text{-Y}^{3+}\text{-}^{11}\text{CuO}_2$  bound to one another by powerful electrostatic forces, on two sides separated from a nonstoichiometric layer  $^{11}\text{Cu}_{0.5+y}$  by neutral  $\text{BaO}$  layers. An oxidation state  $\text{Cu}^{2.5+}$  in the triplet, not dependent on stoichiometry, corresponds to a minimum of electrostatic energy. The equality of concentrations of

electrons  $^{11}\text{Cu}^{2+}$  and holes  $^{11}\text{Cu}^{3+}$  creates optimal conditions for normal conductivity and evidently superconductivity along the  $^{11}\text{CuO}_2$  layers. In turn the friable layers  $^{11}\text{Cu}_{0.5+y}$  ensure a rapid diffusion of metal and especially oxygen in the synthesis of a compound of initial oxides and also subsequent lower-temperature annealing, necessary for oxidating part of the copper to  $\text{Cu}^{3+}$  and homogenization of the ceramic. Figure 1; references 17; 13 Russian, 4 Western.

**Research on Bolometric Properties of Films of Composition Y-Ba<sub>2</sub>-Cu<sub>1-x</sub>-O<sub>7-x</sub>**

*Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОЙ ФИЗИКИ in Russian Vol 14 No 20, 26 Oct 88 (manuscript received 2 Aug 88) pp 1836-1838*

[Article by S. V. Gaponov, M. A. Kalyagin, L. V. Malysheva, S. A. Pavlov, D. G. Pavelyev, A. D. Tkachenko, I. A. Khrebtov and A. Yu. Churin, Applied Physics Institute, USSR Academy of Sciences, Gorkiy]

[Abstract] Due to the discovery of high-temperature superconductors (HTS) it has been possible to develop bolometers operating at a nitrogen cooling level. This article gives the results of research on the bolometric properties of HTS films. Films with the composition  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  with a thickness 1500 Å were applied from a target of the same composition on a monocrystalline backing of  $\text{TiSrO}_3$ . The sensing area of the sensing elements was in the form of a meander measuring  $1000 \times 1000 \mu\text{m}$  with a period  $100 \mu\text{m}$  and  $100 \times 100 \mu\text{m}$  with a period  $10 \mu\text{m}$ . The  $\text{TiSrO}_3$  backing with a thickness 0.3-1 mm was joined on the rear side to a copper foil  $100 \mu\text{m}$  thick. This ensemble was glued on a copper base 8 mm in diameter with a height 5 mm which was mechanically attached to a copper holder in contact with the bottom of a nitrogen cryostat tank. A wire heater maintained sample working temperature in the range 77-100 K. The experimental data obtained in this process (described in detail) indicate the possibility of fabricating bolometers based on HTS films with a threshold response two orders of magnitude better than for uncooled bolometers. Figures 2; references 3: 2 Russian, 1 Western.

**Josephson Effect in Thin Films of High-Temperature Superconductors at 77 K**

*18620044b Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОЙ ФИЗИКИ in Russian Vol 14 No 14, 26 Jul 88 (manuscript received 14 Apr 88) pp 1256-1260*

[Article by A. I. Golovashkin, A. L. Gudkov, S. I. Krasnosvobodtsev, L. S. Kuzmin, K. K. Likharev, Yu. V. Maslennikov, Yu. A. Pashkin, Ye. V. Pechen, and O. V. Snigirev]

[Abstract] An experimental study of thin films of high-temperature superconductors was made concerning the feasibility of attaining a high-grade weak-links structure by conventional photolithography. For this purpose,

500-1,000 nm thick  $\text{YBa}_2\text{Cu}_3\text{O}_x$  films characterized by a high critical current of  $10^4$ - $10^5 \text{ A/cm}^2$  at 77 K temperature were deposited on  $\text{LiNbO}_3$  substrates by laser sputtering of a  $\text{YBa}_2\text{Cu}_3\text{O}_x$  bulk target. Microbridges 0.010 mm long and 0.002-0.010 mm wide were then formed by conventional photolithography: drying the FP 51 MD photoresist at 70 deg C for 1 h, developing it in aqueous 1 pct KOH solution, and etching the film with aqueous 1 pct  $\text{HNO}_3$  solution. Their current-voltage characteristics were measured at 4.8 K and 77 K temperatures under quiescent conditions as well as in an 8 GHz microwave field whose relative power was varied from -70 dB to 7 dB at 4.8 K and to -10 dB at 88 K for a 0.010 mm wide microbridge. These measurements yielded current-voltage characteristics of a Josephson weak-link structure at 4.8 K and at 77 K, but at the higher temperature a much higher characteristic voltage and a first current step blurred much more than by "fluctuations" only. The critical current, two orders of magnitude higher at 77 K than at 4.8 K, was found to depend on the magnetic field intensity as a periodic function of the latter in a field parallel to the plane of the film and perpendicular to the lines of current. Figures 3; references 7: 3 Russian, 4 Western.

**Detection of Thermal Radiation at Liquid-Nitrogen Temperatures With Bolometric Cells of Y-Ba-Cu-O High-Temperature Superconductor Thin Films on SrTiO<sub>3</sub> Substrate**

*18620044c Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОЙ ФИЗИКИ in Russian Vol 14 No 14, 26 Jul 88 (manuscript received 5 Apr 88) pp 1268-1271*

[Article by V. N. Alfeyev, A. S. Aleksandrov, N. S. G. Galkin, A. A. Ivanov, A. V. Kulakov, Yu. V. Lichagin, A. A. Malyuk, V. B. Piskunov, Ye. A. Protasov, V. T. Khryapov, and A. N. Yurkov, Moscow Institute of Engineering Physics]

[Abstract] An integral multicell bolometric detector of thermal radiation at liquid-nitrogen temperatures was built with  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  high-temperature superconductor thin films on a  $\text{SrTiO}_3$  single crystal as substrate, the first such device with NbN superconductor thin films on a  $\text{SrTiO}_3$  substrate having been designed, built, and tested earlier. Films of a 100-800 nm thickness were deposited from a bulk target by sputtering the latter with laser radiation pulses, the temperature of the substrate being varied over the 500-950 deg C range depending on the target-to-substrate distance and on the laser performance characteristics. The films had an electrical resistivity of the order of  $10^4 \text{ ohm.cm}$  at 100 K, independent of the substrate orientation. Their superconducting transition began at 91-85 K and occurred within a 1.5-2 K wide temperature range. The critical current density at liquid-nitrogen temperatures ranged from  $10^4$  to  $5 \cdot 10^5 \text{ A/cm}^2$ . Resistive contact tabs of either Ag or In were deposited as before on NbN films. Measurements were made with the  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  cells interconnected on a passive integral leucosapphire base inside a Dewar flask

with a Ge window. The test stand included a 100 W radiation source with a  $\text{CO}_2$ -laser, a modulator of thermal flux, an optical bench, a low-noise amplifier, a nanovoltmeter, and an instrument for measuring the transport current and recording the critical current. At an 86 K temperature and with a 10 Hz modulation frequency, a current of 1 mA produced an output signal voltage of 0.002 mV. The authors thank V.I. Stafeyev, N.F. Koshchavtsev, M.A. Batalina, T.V. Potapenko, Yu.L. Sazonov, and A.R. Merkertumyants for helpful discussions and for assistance in setting up the experiment. Figures 2; references 5: 3 Russian, 2 Western.

**Emission of High-Energy Radiation in Alkali-Halogenide Crystals Upon Their High-Power Electron Bombardment in Pulses of Nanosecond Duration**

18620044d Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 14, 26 Jul 88 (manuscript received  
29 Jan 88) pp 1275-1277

[Article by V. F. Pichugin and V. F. Stolyarenko, Tomsk Polytechnic Institute imeni S. M. Kirov]

[Abstract] An experimental study of pure LiF, NaCl, KCl, KBr, KI crystals and doped NaCl:Cu, NaCl:Sr crystals was made concerning emission of high-energy radiation upon bombardment by high-energy electron beams in short pulses. The thickness of all crystals by far exceeded the mean free path for 0.25-0.3 MeV electrons coming from an accelerator in single pulses. The current density of the electron beam was varied over the 0.2-1 kA/cm<sup>2</sup> range and the duration of the pulses was varied over the 3-30 ns range. Brittle fracture of crystals occurred upon bombardment by an electron beam with an energy exceeding the critical level of 2.5-5 J/g. Crystal fragments were, 20 s after bombardment, placed on RT-1 x-ray film and the latter was wrapped in black paper. After several hours, the film was developed and only the one holding NaCl:Cu crystals was found to have been exposed to high-energy radiation. The emission threshold coincided with the fracture threshold, but the radiation could not have been generated during fracture occurring within a fraction of a millisecond thus prior to exposure of the film. It must have been generated in those inner regions of the fracture zone where the excited state still existed long after cessation of electron bombardment. Figures 1; references 3: Russian.

**Quantum Characteristics of Electromagnetic Effect in 123-Phase Y-Ba-Cu-O Ceramics**

18620044e Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 14, 26 Jul 88 (manuscript received  
14 Apr 88) pp 1277-1280

[Article by V. F. Pichugin and V. F. Stolyarenko]

[Abstract] An experimental study of 123-phase Y-Ba-Cu-O ceramics was made, for the purpose of determining the dependence of absorbed microwave radiation power

in a modulated weak magnetic field such as the terrestrial one on both the power of an incident microwave radiation field and the amplitude of modulating magnetic field. The temperature dependence of the direct voltage across a specimen, measured inside a 9.5 GHz microwave cavity, reveals a "reverse" Josephson effect and thus validates the representation of such a superconductor ceramic as a multiply-connected Josephson medium. The electromagnetic effect, perceivable when the specimen is located where the H-component of the microwave radiation field peaks and measured in a 100 kHz modulating magnetic field, further validates this representation and indicates that each cell of the superconducting lattice behaves as an analog of a high-frequency or resistive SQUID. Accordingly, there can occur quantum oscillations of the absorbed microwave radiation power in its dependence on the intensity of the H-component of the incident microwave field and on the amplitude of the modulating magnetic field. The authors thank A.G. Aronov for fruitful discussion, A.I. Yegorov and S. E. Khabarov for supplying the specimens. Figures 2; references 5: 3 Russian, 2 Western.

**Effect of Superconducting Transition on Luminescence Quantum Yield From Adsorbed Dye**

18620018b Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 2, 25 Jul 88 (manuscript  
received 23 May 88) pp 89-91

[Article by I. A. Yurchenko, V. Z. Lozovskiy, S. A. Shilo, and O. M. Getsko, Institute of Semiconductors, UkSSR Academy of Sciences]

[Abstract] A new method of studying high-temperature superconductor materials is proposed, namely wetting the superconductor surface with an organic dye and analyzing the luminescence of adsorbed dye molecules during superconducting transition of the substrate. The method was tested on Y-Ba-Cu-O bulk ceramic and on Y-Ba-Cu-O epitaxial film with the critical superconducting transition temperature 50 K and 87 K respectively, also on NbN film with the critical superconducting transition temperature 13.5 K. Following adsorption of erythrosin from a  $10^{-5}$  mole/liter solution for 40 min, its molecules were excited with light at the 510 nm wavelength from a Cu-vapor laser. The luminescence spectrum of this dye and at the same time the magnetic susceptibility of the substrate material were measured at 180-4.2 K temperatures, for establishment of a correlation between the temperature dependence of the luminescence quantum yield from the adsorbed dye and the superconducting transition of the absorbent material. A comparison of the results with those of a theoretical analysis reveals some anomalies in the temperature dependence of the luminescence quantum yield, these anomalies in the temperature dependence of the luminescence quantum yield, these anomalies being attributable to nonhomogeneity of the absorbent and the consequent spreading of its superconducting transition over an approximately 30 K wide temperature range and also



to anomalously large current-current correlators determining its dielectric permittivity function in accordance with the fluctuation-dissipation theorem. Figures 1; references 4: 2 Russian, 2 Western (1 in Russian translation).

#### Fluctuations of Magnetization in $\text{La}_2\text{CuO}_{4-x}$ Structure

18620018c Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 2, 25 Jul 88 (manuscript  
received 2 Jun 88) pp 96-99

[Article by V. Ye. Katayev, Ye. F. Kukovitskiy, Yu. I. Talanov, and G. B. Teytelbaum, Kazan Institute of Engineering Physics, USSR Academy of Sciences]

[Abstract] An experimental study of polycrystalline  $\text{La}_2\text{CuO}_{4-x}$  compounds with varying oxygen deficiency was made concerning their magnetic state and the cause of magnetization fluctuations in the presence of oxygen vacancies, already a small oxygen deficiency  $d$  of the order of 0.03 or even a smaller than 0.03 oxygen excess known to raise the Neel temperature from 0 to 290 K. Magnetic measurements were made first on stoichiometric  $\text{La}_2\text{CuO}_4$  powder with approximately zero oxygen deficiency, its individual grains oriented by a strong magnetic field and "frozen" in paraffin, then on the same powder with an oxygen deficiency produced by annealing at 950 deg C in air. The temperature dependence of the magnetic susceptibility with or without oxygen deficiency was characterized by a Curie jump below 50 K within a 1-3 K wide temperature range in each case and a change of slope characteristic of transition into the antiferromagnetic state at 250 K corresponding to the Neel point in the case of oxygen deficiency. The results are interpreted in terms of a weak antiferromagnetic resonance in structures where long-range magnetic order cannot exist, namely in a structure without oxygen deficiency or in one with oxygen deficiency at temperatures above the Neel point. This has been confirmed by EPR-spectroscopy at a frequency of 9400 MHz in a magnetic field of 1.5 kOe intensity, the 380 G wide resonance line detected in the spectrum of powder with oxygen deficiency below 90 K remaining as wide down to 7 K temperature. The authors thank V. L. Pokrovskiy for helpful discussion. Figures 3; references 10: 2 Russian, 8 Western.

#### Superconductivity of Semiconductor Superlattices on Lead Chalcogenides

18620018d Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 2, 25 Jul 88 (manuscript  
received 8 Jun 88) pp 100-102

[Article by O. A. Mironov, B. A. Savitskiy, A. Yu. Sispatov, A. I. Fedorenko, A. N. Chirkin, S. V. Chistyakov, and L. P. Shpakovskaya, Institute of Radiophysics and Electronics, UkSSR Academy of Sciences, and Kharkov Polytechnic Institute imeni V. I. Lenin]

[Abstract] An experimental study of superlattice structures on Pbs, PbSe, PbTe compound semiconductors

was made concerning the possibility of a superconducting transition at temperatures above 1 K, only below which each of these compounds alone can be made superconducting when strongly doped with an acceptor. For the purpose of simulating the multilayer structure of high-temperature superconductors, three series of binary thin-film superlattices were produced by vacuum evaporation (oilless vacuum of  $10^{-4}$ - $10^{-5}$  Pa) and subsequent vapor deposition. Such superlattices consisting of 1-30 nm thick PbSe and PbS films, PbTe and PbS films, PbTe and PbSe films, 2 to 20 pairs in a superlattice, were deposited on a (001) face of KCl crystals and on a (111) face of  $\text{BaF}_2$  crystals. For control purposes, single films of each compound were produced as thick as the entire corresponding multilayer stack. The structures were examined under an electron microscope and in an x-ray diffractometer, their electrical conductivity and Hall coefficient as well as anisotropy of their transverse magnetoresistivity were measured with direct current over the 300-1.5 K temperature range in a magnetic field of up to 15 kOe intensity. The critical superconducting transition temperature was found to be highest for PbTe-PbS/(001)KCl superlattices, namely 4.5 K with a crossover from three-dimensional to two-dimensional superconductivity at 3.8 K in such a superlattice with nine 15 nm thick PbTe layers and nine 16 nm thick PbS layers. The disparity between lattice periods of layers was also largest, up to 8.3 percent, in these superlattices with a correspondingly high periodic disparity dislocation potential. Figures 3; references 6: Russian.

#### Macroscopic Theory of Superconductors With Small Coherence Length

18620009d Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 7, Jul 88 (manuscript  
received 25 Feb 88) pp 355-374

[Article by L. N. Bulayevskiy, V. L. Ginzburg, and A. A. Sobyenin, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences]

[Abstract] The original Ginzburg-Landau Psi-theory is extended for construction of a macroscopic theory of high-temperature superconductors, a characteristic of these materials being a small coherence length  $\xi$  at zero absolute temperature and thus a small ratio of that length to the interatomic or interelectronic distance. First ignoring thermal fluctuations, the fundamental relations in the Psi-theory are extended to superconductivity of anisotropic superconductors. Thermal fluctuations are considered next and, by the method of perturbation theory is calculated the width of the temperature range of superconducting transition. An analysis based on these concepts leads to a macroscopic theory of superconductivity within that range. The mathematical apparatus of differential-difference equations is then applied to multilayer superconductors generally and high-temperature superconductors specifically, for an interpretation of available experimental data on the

YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-δ</sub> material and calculation of its phenomenological parameters  $t_{G,r}$ . Tables 1; references 48: 31 Russian, 13 Western (2 in Russian translation).

#### Superconductivity of Bi-Sr-Ca-Cu-O Bulk and Film Ceramics

18620017b Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 1, 10 Jul 88 (manuscript  
received 4 Apr 88) pp 19-20

[Article by A. A. Sukhanov, Kh. R. Ozmanyany, and B. B. Sandomirskiy, Institute of Radio Engineering and Electronics, USSR Academy of Sciences]

[Abstract] An experimental study of Bi(Sr<sub>1-x</sub>Ca<sub>x</sub>)<sub>2</sub>Cu<sub>3</sub>O<sub>y</sub> ceramics was made, for the purpose of determining the temperature dependence of their electrical resistivity, magnetic susceptibility, and critical current density. Bulk specimens 3 mm high and 10 mm in diameter with x ranging from 0.0 to 1.0 were produced from Bi<sub>2</sub>O<sub>3</sub> or Bi and SrO, CaO, CuO powder mixtures by compaction, heating to 850-950 deg C, holding at these temperatures for 2 h, and cooling slowly to room temperature within 10-12 h. Their electrical resistance was measured by the voltage-current method with direct current and with alternating current. Their magnetic susceptance was measured by the resonance method with a bridge. The best material was found to be Bi(Sr<sub>0.8</sub>Ca<sub>0.2</sub>)<sub>2</sub>Cu<sub>3</sub>O<sub>y</sub>, its superconducting transition beginning already at 96 K and ending at 84 K, these temperatures becoming lower with either decreasing or increasing Ca content. Film specimens 0.200-0.250 mm thick with Ca<sub>0.25</sub> and with Ca<sub>0.5</sub> were deposited on sapphire substrates from powder mixture heated to a temperature above the melting point, 900-950 deg C. Their critical temperature decreased with increasing current, the temperature at the center of the superconducting transition range being 77 K and the critical current density at 4 K being 25 A/cm<sup>2</sup>. The volume fraction of the superconducting phase was, according to magnetic measurements 40-50 pct. Figures 2; tables 1; references 1: Western.

#### Magnetic Characteristics of La<sub>2</sub>CUO<sub>4-δ</sub> Having La<sup>3+</sup>-ion Deficiency and Containing Magnetic Impurities

18620017c Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 1, 10 Jul 88 (manuscript  
received 7 May 88) pp 21-24

[Article by A. N. Bazhin, V. N. Bezv, and E. A. Tishchenko, Institute of Problems in Physics, V. A. Merzhanov, Institute of Chemical Physics, and I. S. Shaplygin, Institute of General and Inorganic Chemistry, USSR Academy of Sciences]

[Abstract] An experimental study of La<sub>2</sub>CUO<sub>4-δ</sub> was made, its purpose being to determine the field dependence and the temperature dependence of its magnetic

moment and magnetic susceptibility. The x,y,z-components of the magnetic moment were measured with a magnetometer, the specimen vibrating, in an external magnetic field of 0-63 kOe intensity at temperatures up to 100 K. The magnetic susceptibility was measured with Faraday scales in a magnetic field of 8 kOe intensity at temperatures of 4.2-300 K. Polycrystalline specimens were pure. Single crystals contained approximately 0.1 percent other metal ions, principally Fe<sup>3+</sup>-ion content and an approximately 10 percent higher than stoichiometric oxygen content owing to technological difficulties. The temperature of phase transition into the antiferromagnetic state was identified as the temperature corresponding to attainment of maximum magnetic susceptibility. The results reveal a peaking of the magnetic moment over the 40-60 kOe range of magnetic field intensity, when the H-vector is oriented parallel to any of the binary axes b or c and the temperature is below that phase transition point. The authors thank A. S. Borovik-Romanov for formulating the problem, taking interest, and discussing the results, also N. M. Kreynes and I. F. Shchegolev (corresponding member, USSR Academy of Sciences) for interest in the study and discussion of the results, candidate of physical and mathematical sciences N. K. Belskiy and candidate of chemical sciences L. I. Ochertyanova (both at the Institute of General and Inorganic Chemistry, USSR Academy of Sciences) for chemical analysis of specimens, G. A. Yemelchenko (Institute of Solid-State Physics, USSR Academy of Sciences) for growing and supplying La<sub>2</sub>CUO<sub>4-δ</sub> single crystals, and Yu. M. Orekhov (Institute of Semiconductor Physics, USSR Academy of Sciences) for determining the orientation of their axes. Figures 3; references 5: 1 Russian, 4 Western.

#### Interaction of Superconductor Current and Moessbauer Radiation

18620017d Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 1, 10 Jul 88 (manuscript  
received 7 May 88) pp 25-26

[Article by V. N. Belogurov, A. N. Borzyak, and N. N. Karlinlysh, Institute of Physics, LaSSR Academy of Sciences]

[Abstract] An experimental study of a YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7</sub> superconducting ceramic in contact with a normal conductor containing a Moessbauer gamma-radiation source has confirmed the theory that change in recoilless gamma-radiation emission by such a source depends on the direction of current flow, to it or from it. According to this model, a Cooper pair decays into two free electrons and one phonon upon its transfer from a superconductor to a normal conductor and the additional phonon appearing in the normal conductor causes recoilless radiation emission by a source in the latter to decrease. With the radiation absorber at resonance with the radiation source, resonant absorption then decreases and the radiation quanta count by a detector behind the absorber increases. The experiment was performed with

a  $\text{YBa}_2\text{Cu}_3\text{O}_7$  ceramic and a  $^{57}\text{Co}$  Moessbauer source in Cr, a plate of stainless steel serving as Moessbauer absorber. Measurements were made at 77 K liquid-nitrogen temperature and thus below the 90 K critical superconducting transition temperature for the ceramic, with an electron current of 20 mA passed through the system in both direction as well as the zero current and pulses from a differential discriminator counted in each case. According to the theory, confirmed by this experiment, the pulse count should be lower with electrons flowing from normal conductor to superconductor than with electrons flowing the reverse direction and should be lower than or equal to the pulse count with no current flowing but Cooper pairs possibly transferring to the normal conductor by diffusion. Tables 1; references 1; German.

**Hall Effect and Thermo-E.M.F. in  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$  and  $\text{HoBa}_2\text{Cu}_3\text{O}_{7-\delta}$  Single-Crystal Films**

18620017e Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 1, 10 Jul 88 (manuscript  
received 10 May 88) pp 27-29

[Article by A. I. Golovashkin, S. I. Krasnosvobodtsev, I. V. Kucherenko, and Ye. V. Pechen, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences]

[Abstract] An experimental study of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$  and  $\text{HoBa}_2\text{Cu}_3\text{O}_{7-\delta}$  single-crystal films was made concerning the temperature dependence of their Hall coefficient and thermo-e.m.f., 200-1300 nm thick films having been grown on  $\text{SrTiO}_3$  substrates with the 001 -axis perpendicular to the surface of the latter. Their critical superconducting transition temperature varied from 91 K to 78 K, with a 0.5 K wide transition range, and their electrical resistivity at 100 K was 0.060-0.150 mohm.cm. Both thermo-e.m.f. and Hall e.m.f. were measured by the compensation method with Cu-constantan thermocouples under a temperature gradient of 1-3 K. The results are consistent with an inverse power-law temperature dependence of the Hall mobility and with a hall coefficient independent of the magnetic field intensity. At temperatures below 300 K the mean free path is evidently longer than the distance between nearest atoms in the Cu-O plane, which indicates a consistency with the Boltzmann equation of kinetics, while the trend of the temperature dependence of the thermo-e.m.f. indicates an appreciably electron-phonon interaction. Figures 3; references 12: 3 Russian, 9 Western.

**Spectra of Raman Light Scattering in Bi-Sr-Ca-Cu-O High-Temperature Superconductors**

18620017f Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 1, 10 Jul 88 (manuscript  
received 19 May 88) pp 33-35

[Article by T. A. Fimberg, E. R. Ioon, Ya. O. Past, and L. A. Rebane, Institute of Chemical Physics and Biophysics, USSR Academy of Sciences]

[Abstract] An experimental study of Bi-Sr-Ca-Cu-O ceramics with various stoichiometries was made involving measurement of their Raman spectra, also determination of the temperature dependence of their electrical

resistivity for direct current and diamagnetic shielding at high frequency. Specimens were produced from dry pure  $\text{Bi}_2\text{O}_3$ ,  $\text{SrO}$ ,  $\text{CaO}$ ,  $\text{CuO}$  powders by thorough mixing. The powder mixtures were heated to and held for 20-24 h at 825-855 deg C ( $T_1$ ) in air, then compacted. The compacts were heated to and held for 20-24 h at 860-870 deg C ( $T_2$ ) in an oxygen stream, then slowly cooled in the furnace. Three specimens were thus produced: 1)  $\text{Bi}_2\text{Sr}_3\text{Ca}_2\text{Cu}_4\text{O}_{11+\delta}$  by heating to 855 deg C ( $T_1$ ) and 870 deg C ( $T_2$ ), 2)  $\text{Bi}_6\text{Sr}_7\text{Ca}_2\text{Cu}_6\text{O}_{24+\delta}$  by heating to 830 deg C ( $T_1$ ) and 870 deg C ( $T_2$ ), 3)  $\text{Bi}_8\text{Sr}_7\text{Ca}_2\text{Cu}_6\text{O}_{24+\delta}$  by heating to 825 deg C ( $T_1$ ) and 860 deg C ( $T_2$ ). Their electrical resistivity at room temperature was 10 mohm.cm. The first specimen was nonmetallic in behavior, without superconducting transition at all. The other two specimens became superconducting, their critical temperature being 70 K and 80 K respectively, based on electrical resistivity and on diamagnetic shielding at a frequency of 29 MHz. Measurement of the Raman spectra was done over the 60-1100  $\text{cm}^{-1}$  range in an OMARS-89 multichannel spectrometer at room temperature, upon excitation at the 514.5 nm line of an  $\text{Ar}^+$ -laser with a power of up to 50 mW focused on a spot 0.050 mm in diameter. In addition were also measured the Raman spectra of  $\text{Bi}_2\text{O}_3$ , also of  $\text{Cu}_2\text{O}$  and Bi-Cu-O ternary compounds as likely byproducts of the synthesis reaction. The authors thank Academician K. K. Rebane for helpful discussions and A. M. Vaynrub for assistance in measurement of diamagnetic shielding. Figures 2; references 10: 2 Russian, 8 Western.

**Electronic Properties of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$  System**

18620017g Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 1, 10 Jul 88 (manuscript  
received 23 May 88) pp 36-38

[Article by I. A. Garifullin, N. N. Garifyanov, and G. G. Khaliullin, Kazan Institute of Engineering Physics imeni Ye. K. Zavoyskiy, USSR Academy of Sciences, A. V. Mitin, N. Ye. Alekseyevskiy and V. I. Nizhankovskiy, Institute of Problems in Physics, USSR Academy of Sciences, B. I. Kochelayev and L. R. Tagirov, Kazan State University, and Ye. P. Khlybov, Institute of High-Pressure Physics, USSR Academy of Sciences]

[Abstract] An experimental study of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$  ceramics was made, for the purpose of determining the changes of their properties with change of their oxygen deficiency  $\delta$  over the 0.15-0.5 range. Polycrystalline specimens with a small oxygen deficit were produced from  $\text{Y}_2\text{O}_3$ ,  $\text{BaO}$ ,  $\text{CuO}$  powders by the standard technology. Their oxygen deficiency was then increased by heating to and holding at 900 deg C for 3 h under a low  $\text{O}_2$  pressure of 5 mm Hg with subsequent fast cooling to room temperature. In a batch of specimens, for EPR-spectroscopy at a frequency of 9200 MHz, gadolinium was added replacing from 1 pct to all of yttrium. Measurements of the EPR-line width over the 50-300 K temperature range as well as of the electrical resistivity and the magnetic susceptibility over the 1.5-300 K



temperature range have revealed an almost "metallic" behavior and a "semiconductor-like" behavior of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  ceramics with a 0.15 oxygen deficit and with a 0.5 oxygen deficit respectively with no diamagnetism in the latter ceramic. With any oxygen deficit, therefore, these ceramics are evidently nonhomogeneous with "metallic" regions surrounded by increasingly large "dielectric" ones. Figures 3; references 5: 2 Russian, 3 Western.

**Split of Superconducting Transition in High-Temperature Superconductors Owing Low Degree of Orthorhombicity**

18620017h Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 1, 10 Jul 88 (manuscript  
received 25 May 88) pp 39-42

[Article by G. Ye. Volovik, Institute of Theoretical Physics imeni L. D. Landau, USSR Academy of Sciences]

[Abstract] The split of superconducting transition into two temperatures ranges separated by a small 3-4 K gap is analyzed theoretically, such a split having been detected in experiments with  $\text{YBa}_2\text{Cu}_3\text{O}_x$  ceramic and found to be analogous to the superfluidity transition in  $^3\text{He-A}$  by an arbitrarily weak magnetic field. The analysis is based on the model of orthorhombic perturbation of the tetragonal crystal lattice, superconductivity being associated principally with  $\text{CuO}_2$  planes and with an electronic system in an almost tetragonal surrounding. Orthorhombic perturbation is caused by remote  $\text{CuO}$  chains as well as by deviations of the  $\text{CuO}_2$  lattice from a square one. Calculations based on this theory yield, after corrections have been made, results which do not contradict the theory that the transition from the normal state is, on account of fluctuations of the electromagnetic field, a phase transition of the first kind and the subsequent transition to the superconducting state is one of the second kind not affected by such fluctuations. Tables 1; references 9: 1 Russian, 8 Western.

**Magnetic Ordering in  $\text{Y}_2\text{BaCuO}_5$  Compound**

18620017i Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 1, 10 Jul 88 (manuscript  
received 26 May 88) pp 43-44

[Article by N. I. Agladze, M. N. Popova, Ye. P. Khlybov, and G. G. Chepurko, Institute of Spectroscopy, USSR Academy of Sciences]

[Abstract] An experimental of a Y-Ba-Cu-O ceramic containing besides the  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  superconductor phase also the green  $\text{Y}_2\text{BaCuO}_5$  semiconductor phase has revealed magnetic ordering in the latter phase at a temperature of 16.5 K. Specimens of  $(\text{Y}_{0.99}\text{Er}_{0.01})_2\text{BaCuO}_5$  powder were examined by the method of optical spectroscopy for absorption and diffuse reflection over the 6500-6900  $\text{cm}^{-1}$  range of  $^4\text{I}_{13/2} \rightarrow ^4\text{I}_{13/2,11/2}$  transitions in the  $\text{Er}^{3+}$  ion at temperatures from 20 K down. The authors thank G. N. Zhizhin and V. V. Yevdokimov for interest. Figures 2; references 3: Western.

**Superconducting Phases With Perovskitic Structure**

18620017j Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 1, 10 Jul 88 (manuscript  
received 8 Apr 88, after revision 2 Jun 88) pp 45-47

[Article by N. Ye Alekseyevskiy, G. M. Kuzmicheva, Ye. P. Khlybov, A. V. Mitin, and V. I. Nizhankovskiy, Institute of Problems in Physics, USSR Academy of Sciences]

[Abstract] Genesis of superconducting phases with a perovskitic structure is overviewed and their systematization is attempted, on the basis of available results of structural and phase analyses as well as available data on the temperature dependence of electrical resistivity and magnetic susceptibility. Such phases have been found in the R-Ba-Cu-O, R-Bi-(Ca,Sr)-Cu-O, R-(Al,Bi)-(Ca,Sr)-Cu-O systems (R- Y or rare-earth element) in the Bi-(Ca,Sr)-Cu-O, Bi-(Ba,Sr)-Cu-O, (Bi,Sb)-(Ca,Sr)-Cu-O, Bi-Pb-(Ca,Sr)-Cu-O systems, and in the Tm-Be-Cu-O system. Figures 2; references 7: 1 Russian, 6 Western.

UDC 533.72:536.758

**Generation of Solitons and Bisolitons in Molecular Systems**

18620059 Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 302 No 3, Sep 88 (manuscript received 6 Jul 87) pp 601-604

[Article by Academician (UkSSR Academy of Sciences) A. S. Davydov and V. N. Yermakov, Institute of Theoretical Physics, UkSSR Academy of Sciences, Kiev]

[Abstract] The molecular mechanism by which solitons and bisolitons are generated at the end of a quasi-one-dimensional soft chain upon impingement of an electron flux on this chain is analyzed on the basis of a simple model: a molecular system consisting of two semiinfinite chains originating at a common point, a soft one and a rigid one. The electron flux is assumed to originate at infinity and to have a density  $D^2$  not higher than unity. First are considered the steady states of excess electrons in both chains. To each level of electron flux density there corresponds a critical energy level, total reflection by the soft chain occurring as long as  $D^2$  is lower than some critical density  $D_m^2$  and nonsteady states forming with attendant generation of solitons inside the soft chain when the critical energy level is exceeded. Next is considered generation of bisolitons in a superconducting system. With Coulomb repulsion ignored, the activation energy for slowly moving paired solitons is found to be lower than that for single ones. The conditions at the end of a soft chain are, therefore, more favorable for generation of bisolitons. This is evidently a two-stage process, incidence of one electron being followed by incidence of a second electron with the same energy but opposite spin. Incidence of the second electron changes the local

state of strain and, correspondingly, doubles the magnitude of the nonlinearity parameter in the nonlinear Schroedinger equation. References 5: Russian.

UDC 536.33:621.1.016

**Comparative Analysis of Numerical Methods of Solving Integral Equations in Inverse Problems of Radiative Heat Transfer**

18620049 Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA TEKHNIЧЕСКИХ НАУК in Russian Vol 15 No 4, Aug 88 (manuscript received 16 Mar 87) pp 3-10

[Article by Ye. K. Belonogov and A. Yu. Zatselin, Scientific Research Institute of Problems in Machine Design, Moscow Higher Technical School imeni N. E. Bauman, Moscow]

[Abstract] Five numerical methods of solving integral equations of the first kind are evaluated comparatively for stability and accuracy of the solution. They are applied specifically to the Fredholm integral equation of the first kind to which inverse problems of radiative heat transfer in a system of bodies with gray surfaces are reducible, considering that these problems may be ill-conditioned for calculation of radiant fluxes when the density distributions of the incident radiant flux over all or some surfaces are given. As the test problem has been selected that of two equally wide and infinitely long parallel plates for which the density distributions of the incident radiant flux had been determined from the solution to the forward problem. On this problem, assuming no perturbation of the input data, were tested the Lavrentyev method of regularization into a Fredholm integral equation of the second kind first and the zeroth-order Tikhonov method of regularization without use of apriori information, both methods involving reduction to an approximating system of linear algebraic equations, also the Picard method of spectral slicing. Most adequate is found to be the Tikhonov method, the Lavrentyev method yielding much less satisfactory results and the Picard method being entirely unsuitable here. On the same problem were also tested two methods involving use of information about the accuracy of discrete approximation of the original operator and application of the generalized discrepancy principle, the method of conjugate gradients (PTIZR program) yielding here somewhat more accurate results than the difference factorization method (PTIMR program). Figures 6; references 17: 16 Russian, 1 Western.

**Once More About Ambiguity of Predictions of General Relativity Theory**

18620036a Moscow *TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA* in Russian  
Vol 76 No 2, Aug 88 (manuscript received 1 Feb 88)  
pp 163-168

[Article by A. A. Logunov and Yu. M. Loskutov, Moscow State University]

[Abstract] Predictions concerning gravitational effects and based on the general relativity theory are considered, such predictions having been earlier shown by the authors to be ambiguous but other authors (S. Ichinose and Y. Kaminaga: RIMS-597, Kyoto University, 1987) insisting that they are not. This claim is now shown to be flawed, because it ignores the fundamental distinction between transformations of the radial variable in solution of the Hilbert-Einstein equations in assigned coordinates and the multiplicity of equally valid solutions of these equations. A case in point is the gravitational delay of a radio signal propagating from one point to another within the field of a spherisymmetric central body having a certain mass. For the purpose of proving that prediction of this delay based on the general relativity theory is ambiguous, space is arithmetized as a way of plain enumeration of points on the given manifold on

which the appropriate geometry can then be constructed. The authors thank M. Ye. Gertsenshteyn and M. A. Mestvirishvili for discussions. References 5: 4 Russian, 1 Western.

**Exact Solutions in Relativistic Gravitation Theory**

18620036b Moscow *TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA* in Russian  
Vol 76 No 2, Aug 88 (manuscript received 22 Jan 87)  
pp 304-313

[Article by K. A. Bronnikov and G. N. Shikin, All-Union Scientific Research Center for Study of Surface and Vacuum Properties]

[Abstract] Mathematical field models including gravitation are analyzed for exact particle-like solutions, the equations of relativistic gravitation theory being formulated for spherisymmetric system with regular center such as dust carrying both electric and scalar charges. Following a review of Schwarzschild, Reissner-Nordstrom, and Fisher solutions, interaction of a scalar field and an electromagnetic one is considered with two variants of its Lagrangian. Regular solutions to the Hilbert-Einstein equations are then used for formulation of nonlinear electrodynamics with gravitational conditionality. References 11: 7 Russian, 4 Western.



UDC 517.4

**Holonomic Systems With Regular Singularities  
and Wavefronts of Feynman Integrals**

18620024b Moscow FUNKTSIONALNYY ANALIZ in  
Russian Vol 22 No 3, Jul-Sep 88 (manuscript received  
31 Mar 87) pp 71-72

[Article by A. I. Zaslavskiy, Nizhniy Tagil Pedagogical  
Institute]

[Abstract] Three theorems are proved pertaining to holonomic systems of differential equations with regular singularities and to wavefronts of Feynman integrals on a real-analytic manifold, any Feynman integral being the solution to such a system of equations and, therefore, the corollary following that the wavefront of such an integral is also its analytic wavefront. References 6: Western (1 in Russian translation).

UDC 519.68

**Optimization of Algorithm of Extremum Search  
by Complex Method**

18620065 Moscow ZAVODSKAYA LABORATORIYA  
in Russian Vol 54 No 10, Oct 88 (manuscript received  
2 Nov 87) pp 86-90

[Article by V. S. Levshanov]

[Abstract] Solution of a general problem of nonlinear programming by the M. J. Box complex method is considered, the problem being to find the minimum of a target function in a  $k$ -dimensional Euclidean space of variables under given constraints of the first kind so that constraints of the second kind will be satisfied. A modification of the original algorithm of this method is proposed which will optimize it in terms of faster convergence and, consequently, shorter computer time. The initial complex is constructed so as to facilitate movement in a direction close to that of the antigradient and, therefore, not as an irregular figure with  $k$  plus 1 or more vertices but as a polyhedron with not too many vertices uniformly spaced within the allowable region. Following sufficiently many exploratory tests, the polyhedron is placed near the optimum point. The number of subsequent iterations is thus reduced, especially on smooth unimodal surfaces, when the minimum is far away. The

six steps of this new algorithm are: 1) determine the coordinates of the vertices of the initial complex, 2) estimate the magnitudes of the components of the vector-gradient pointing to the response surface of the target function, 3) determine the coordinates of the center of the complex constructed without the "worst" (1-th) vertex, 4) calculate the angles which the vector-gradient makes with the directions in which the 1-th point is reflected through pertinent centers of the complex, 5) determine the coordinates of the reflected points, 6) verify the conditions for terminating the procedure. The conditions for optimality of this new algorithm are established for three Himmelblau test functions, by comparing all possible variants of construction of the initial complex with use of one and the same sequence of pseudorandom points uniformly spaced on the (0,1) interval or with use of the first 256 trial points of the  $LP_{100}$ -sequence. Optimum in terms of most efficient minimization of all three test functions are found to be use of the  $LP_{100}$ -sequence and reflection of the "worst" point through the center "of mass" rather than through the center "of differential masses" or the geometrical center. The optimum weight coefficient and reflection coefficient for all three test functions are 1.0 and 1.3 respectively. Taking into account the direction of the vector-gradient is most effective in the case of a function of many variables. Tables 1; references 15: 4 Russian, 11 Western (3 in Russian translation).

**Multisoliton Components of Solutions of Nonlinear Schrodinger Equation With Perturbing Term**

18620118a Moscow *TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA* in Russian  
Vol 78 No 1, Jan 89 (manuscript received 6 Jul 87)  
pp 35-44

[Article by V. A. Vysloukh and I. V. Cherednik, Interfaculty Problems Scientific Research Laboratory of Molecular Biology and Bioorganic Chemistry imeni A. N. Belozerskiy; Moscow State University]

[Abstract] The authors have clarified some aspects of the problem related to the number of soliton effects arising during the propagation of ultrashort optical pulses in single-mode fiber light conductors. In the picosecond range of durations the transformation of the complex amplitude of the time envelope  $r(x, t)$  with a high degree of accuracy is described by the Cauchy problem for a nonlinear Schrodinger equation (NSE) of a specific form. Use of traditional numerical schemes for integration of the NSE or methods based on the inverse scattering problem approach makes it possible to obtain detailed information on the dynamics of the time envelope in both the near and in the distant field. However, with a decrease in the initial pulse duration to the femtosecond range effects associated with the nonlinear dispersion of group velocity become important, necessitating use of a modified equation for a refined model. The problem was solved on the basis of the integrability of this modified equation by the inverse scattering problem method, making it possible to obtain its multisoliton solutions, being a nonlinear superposition of single-soliton solutions. Single-soliton solutions are of great practical importance because they are characterized by stability of the modulus of the envelope and a constancy of group velocity. These solutions degenerate with  $\beta \rightarrow 0$  into multisoliton solutions of the NSE. However, as demonstrated here, their structure and a number of properties differ from the structure and properties of the corresponding solutions of the fundamental, traditional equation. Figures 5; references 8: 5 Russian, 3 Western.

**Stark Effect for Schrodinger Difference Operator**

18620118b Moscow *TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA* in Russian  
Vol 78 No 1, Jan 89 (manuscript received 18 Jun 87)  
pp 70-80

[Article by Ye. I. Dinaburg, Earth Physics Institute imeni O. Yu. Shmidt, USSR Academy of Sciences]

[Abstract] A strongly connected model for electron motion in a uniform electrical field is examined and the spectrum of the corresponding Schrodinger operator, perturbed by the potential of an ideal crystal lattice or potential, decreasing rapidly at infinity, is investigated. It is shown that with typical directions of the vector of strength of the electrical field relative to the base vectors

of the lattice, under the condition of smallness of the perturbation, the Schrodinger operator has a purely point (everywhere dense) spectrum. References 10: 4 Russian, 6 Western.

**Nonlinear Theory of Flame Front Instability**

18620113f Moscow *ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI* in Russian Vol 95 No 1, Jan 89 (manuscript received 28 Jan 88) pp 114-121

[Article by S. K. Zhdanov and B. A. Trubnikov, Atomic Energy Institute imeni I. V. Kurchatov]

[Abstract] The problem of instability of combustion of a gas is examined in the classical purely hydrodynamic Landau-Zeldovich formulation for a plane flame front in a slow combustion regime with essentially subsonic velocities. An appropriate nonlinear equation is derived for this phenomenon which takes into account quadratic corrections describing instability of a plane front under these conditions. It is shown that instability results in a cellular structure of the front, which is qualitatively consistent with observations. Figures 2; references 13: 10 Russian, 3 Western.

UDC 535.31+681.7+517.946

**One Inverse Problem in Formation of Coherent Radiation**

18620077a Moscow *DOKLADY AKADEMII NAUK SSSR* in Russian Vol 303 No 2, Nov 88 (manuscript received 28 Apr 87) pp 279-283

[Article by A. V. Goncharskiy and V. V. Stepanov, Moscow State University imeni M. V. Lomonosov]

[Abstract] Some aspects of the synthesis of laser optical systems for solving various problems in thermal processing, in development of highly effective scanning systems and for other purposes are examined. The research described in the article is centered on computation of phase optical elements for forming the required intensity distribution in a stipulated plane. A mathematical model is outlined, using the Kirchhoff approximation as a point of departure (and later the Fresnel approximation), for solving the inverse problem in the forming of coherent radiation (the scalar wave field  $U(x, y, 0 + 0)$  is found on the basis of a stipulated field intensity in the plane  $z = \ell$ ). Knowing the scalar wave field incident on an optical radiation element  $U(x, y, 0 - 0)$ , it is easy to compute the characteristics of an optical element solving the formulated problem of laser radiation formation. For many practical problems the geometry of an optical system is such that it is desirable to employ the geometrical optics approximation. The inverse problem is reformulated in this approximation and an approximate solution is obtained. It is shown that in a region  $Q_\mu$  on the plane  $z$



=  $f$  it is possible to form a uniform intensity distribution (such a synthesis problem cannot be solved in the Kirchhoff and Fresnel approximations). Figures 2; references: 4 Russian.

UDC 517.964

**New Results in Localization of Solutions of Nonlinear Elliptical and Parabolic Equations Derived by Energy Method**

18620076a Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 303 No 3, Nov 88 (manuscript received 19 Jul 88) pp 524-529

[Article by S. N. Antontsev and J. I. Diaz (Spain), Hydrodynamics Institute imeni M. A. Lavrentyev, Siberian Department, USSR Academy of Sciences, Novosibirsk; Complutans University, Madrid]

[Abstract] New results on the spatial and temporal localization of solutions of nonlinear elliptical and parabolic equations of a general type when they contain "sources," a stipulated right-hand side, are described. The results were obtained by the so-called energy method proposed and validated in a number of earlier studies (S. N. Antontsev, DAN, Vol 260, No 6, pp 1289-1293, 1981, and elsewhere). Such properties of the solution as finite localization time and spatial localization for evolutionary equations, as well as disappearance to zero in the set of a positive measure for elliptical equations, are investigated. The principal objective is a study of equations with a stipulated right-hand side leading to inhomogeneous nonlinear ordinary differential inequalities for energy functions. The method is applicable to systems of equations of the composite type, including those arising in the mechanics of a continuous medium. References 9: 6 Russian, 3 Western.

UDC 517.925

**Singularly Perturbed Systems of Ordinary Differential Equations in Cases When 'Degenerate' Systems Have Discontinuous Solutions**

18620076b Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 303 No 3, Nov 88 (manuscript received 8 Jul 87) pp 546-549

M. I. Imanaliyev, corresponding member, USSR Academy of Sciences, and P. S. Pankov, Mathematics Institute, Kirgiz Academy of Sciences, Frunze]

[Abstract] A study was made of a "degenerate" system having several smooth solutions. Specifically, the article gives an asymptotic representation of solution of the Cauchy problem for a system of ordinary differential equations. The corresponding "degenerate" system has a stable solution  $v(t)$  with a finite number of discontinuities of the first kind. In an earlier study by the authors (ISSLEDOVANIYA PO INTEGRODIFFERENTIALNYM URAVNENIYAM, No 19, pp 3-7, 1986) a study

was made of an asymptotic form of solution of the Cauchy problem for a scalar equation of the form (1), (2) when the solution of the degenerate equation (3), as in this case, has discontinuities at a finite number of points. Later (DAN, Vol 289, No 3, pp 536-538, 1986) the authors demonstrated that if the vector function  $v(t)$  does not have a continuous derivative at the initial point  $t = a$ , the solution of the Cauchy problem for system (1) with some  $f(t, y)$  has a rotating boundary layer. Under these conditions a situation arises when  $\epsilon$  tends to zero and the solution of the problem does not converge to any one of the solutions of the degenerate system (3). The formulated problem is investigated with these findings taken into account. The method employed differs substantially from that given earlier and is a further development of the boundary layer corrections method. The following theorem is examined: the system (3) has some discontinuous solution. Examination of this theorem shows that the Cauchy problem has a unique solution. The principal stages of the proof are outlined. References: 5 Russian.

UDC 517.944:519.46

**Nominal Invariance and Precise Solutions of Nonlinear Equation of Acoustics**

18620089 Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR: SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNIЧЕСKIYE NAUKI in Russian No 10, Oct 88 (manuscript received 30 May 88) pp 27-31

[Article by V. I. Fushchich, corresponding member, Ukrainian Academy of Sciences, and N. I. Serov, Mathematics Institute, Ukrainian Academy of Sciences, Kiev]

[Abstract] In earlier studies by the senior author (UKR. MAT. ZHURN, 39, No 1, pp 116-123, 1987; SIMMETRIYA I RESHENIYA Nelineynykh URAVNENIY MATEMATICHESKOY FIZIKI, pp 4-6, 1987) the following approach was proposed for solving nondifferential equations in partial derivatives (NEPD). It is postulated that some NEPD does not have a nontrivial group invariance. In obtaining solutions of the equation such an additional NEPD is added to it in order that the derived (overdetermined) system has broad symmetric properties. If this can be done, by using the symmetric properties of the system, solutions of the overdetermined system of NEPD can be obtained. Proceeding on this basis, the authors derive several classes of precise solutions of the nonlinear equations of acoustics. All the results presented for a univariate equation can be generalized for a multivariate nonlinear equation of acoustics. References 5: 3 Russian, 2 Western.

**Finite-Zone Solutions of Stationary Axisymmetric Einstein Equation in Vacuum**

18620098b Moscow *TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA* in Russian  
Vol 77 No 1, Oct 88 (manuscript received 21 Apr 87)  
pp 25-41

[Article by D. A. Korotkin, Leningrad State University]

[Abstract] After a historical review of the problem, a new broad class of precise solutions is obtained for the stationary axisymmetric Einstein equation, expressed through theta Riemann functions. The properties of the constructed "finite-zone" solutions differ substantially from the properties of known finite-zone solutions (such as the Korteweg-de Vries equation and the nonlinear Schrödinger equation). In particular, the dependence on dynamic variables in the final formulas is stipulated by a trajectory on the manifold of moduli of algebraic curves, not on the Jacobi manifold of this curve. In a degenerate case the constructed solutions include all the main known solutions, expressed in elementary functions. Figures 3; references 23: 13 Russian; 10 Western.

**Solution to Linear Equations in Spaces of Harmonic Variables**

18620036c Moscow *TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA* in Russian  
Vol 76 No 2, Aug 88 (manuscript received 29 Jan 87)  
pp 169-183

[Article by I. A. Bandos, Kharkov State University]

[Abstract] Explicit solutions to linear first-order differential equations in  $Su(N)/H_c$  spaces are obtained for  $N$  equal to or larger than 3,  $H_c$  equal to  $U_1(1) \dots U_{N-1}(1)$  denoting the Cartan subgroup of the  $SU(N)$  group and the spaces having been parametrized with harmonic variables. Using relevant concepts and notations, general solutions to homogeneous and nonhomogeneous equations are obtained first. The procedure and the results are then applied to kinematic constraints in the supersymmetric gauge theory with  $N$  equal to or larger than 3, this theory being formulated as one of connectedness in stratification over harmonic supermanifolds subject to some number of covariant conditions for connectedness. The author thanks V. G. Zima for interest and many stimulating discussions. Also D. P. Sorokin for discussion. References 16: 8 Russian, 8 Western (1 in Russian translation).

**Analysis of Nonlinear One-Dimensional Systems by Hamiltonian Formalism**

18620036d Moscow *TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA* in Russian  
Vol 76 No 2, Aug 88 (manuscript received 29 Sep 87)  
pp 199-206

[Article by V. G. Mikhalev, Moscow Institute of Steel and Alloys]

[Abstract] Systems describable by the sine-Gordon equation with small perturbations are analyzed by the Hamiltonian formalism with a Poisson bracket, such systems

including not only Josephson junctions but also anisotropic ferromagnetic materials with slowly moving domain walls. The parameters of radiation emission induced by perturbation and motion of solitons are calculated, in the first approximation with respect to amplitude, by differentiation of the Gelfand-Levitan equations. The wave equation for Josephson junctions is then analyzed for the dynamics of fluxons, the corresponding Hamiltonian being obtained with the aid of the monosoliton solution and then extended to systems with inhomogeneities. The not readily integrable modification of the Landau-Lifshitz equation for a cubic ferromagnetic material with weakly axial anisotropy is analyzed with the aid of solutions to the sine-Gordon equation. The author thanks B. A. Dubrovin for interest and helpful discussions. References 13: 7 Russian, 6 Western (3 in Russian translation).

**Asymptotic-in-Time Solution to Cauchy Problem for Landau-Lifshitz Equation**

18620014 Moscow *TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA* in Russian  
Vol 76 No 1, Jul 88 (manuscript received 9 Jan 87)  
pp 3-17

[Article by R. F. Bikbayev and A. R. Is-s, Leningrad State University]

[Abstract] Asymptotic solutions to two problems for the Landau-Lifshitz equation of ferromagnetism within the solitonless sector are analyzed, first solution to the Riemann matrix problem and then solution to the Cauchy problem. On the basis of the isomonodromic  $L^0$ -solution and with monodromy data of the equation in  $\lambda$  are obtained explicit analytical expressions for  $L_1$  and  $L_2$  describing the leading term of the asymptotic-in-time solution  $L(x,t)$  to the Cauchy problem with boundary conditions of  $L_3$  tending to unity and  $x$  tending to plus or minus infinity. References 18: 14 Russian, 4 Western.

UDC 517.91/943

**Quasi-Periodic Solutions to Second-Order Ordinary Differential Equations**

18620004 Alma-Ata *IZVESTIYA AKADEMII NAUK KAZAKHSTANSSKOY SSR: SERIYA FIZIKO-MATEMATICHESKAYA* in Russian No 3, May-Jun 88 (manuscript received 18 Mar 87) pp 45-49

[Article by Zh. Sartabanov, Aktybinsk Pedagogical Institute]

[Abstract] For an analysis of quasi-periodic solutions to a nonlinear second-order ordinary differential equation, such an equation is converted into a multi-periodic system of partial differential ones and the method of fast convergence is applied to the latter. This approach is demonstrated on the equation  $d^2x/dt^2 + \sigma^2 x = f(t, x, dx/dt, \mu)$  with appropriate constraints on time  $t$  (real positive) and coefficient  $\sigma$  (nonzero) as well as on

small parameter  $\mu$ . It is validated by two existence and uniqueness theorems for a periodic analytic solution, with the aid of three lemmas including an inductive one and one of reducibility to a linear equation. References 8: Russian.

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**Differential Equations on Complex Analytic Manifolds and Maslov's Canonical Operator**  
18620006 Moscow *USPEKHI MATEMATICHESKIKH NAUK in Russian Vol 43 No 3 (261), May-Jun 88*  
(manuscript received 24 Mar 87) pp 99-124

[Article by B. Yu. Sternin and V. Ye. Shatalov, Moscow Institute of Computer-Aided Machine Design]

[Abstract] An overview of differential equations on complex analytic manifolds of arbitrary dimensionality is presented, a recapitulation of knowledge gained and advances made on this subject within the past 25 years.

The first topic is integral transformations of multivalued analytic functions, with natural rules of commutation involving operations of differentiation with respect to and of multiplication by the independent variable. The next topic is Maslov's canonical operator, in both local and global theories, followed by "pseudodifferential" (Fourier-Maslov integral) operators of first and second kinds for composition. Next are considered asymptotic behavior of solutions to differential equations and construction of a regularizer as well as asymptotic behavior of the solution to this problem within and beyond the vicinity of the characteristic submanifold  $\text{char } X$  with codimensionality 1. The last topic is an asymptotic solution to the characteristic Cauchy problem on the basis of both local and global theories of Legendre uniformization. Not included in this overview is the subject of integral geometry. The authors thank V.P. Maslov for assistance and advice, and G. M. Khenkin for helpful comments. References 81: 30 Russian, 51 Western (5 in Russian translation).



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